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1961 No. 3 COPEIA September 22

The Perciform Caudal Skeleton

WILLIAM A. GOSLINE

FORD (1937:42) established three criteria for the basic percoid type of caudal skeleton. With the knowledge now available, it seems possible not only to define the basal percoid caudal structure more exactly but to follow to some extent the kinds of specialization which have repeatedly occurred in the more advanced perciform types.

Earlier work (cf., Gosline, 1960b) has demonstrated that the evolution of caudal structure in modern teleostean fishes has been primarily one of progressive simplification from an original complex of rather numerous independent bones (e.g., in *Elops*, Hollister, 1936:261, fig. 14). This progressive simplification has occurred independently in a large number of lineages both within and below the perciform level of structural organization.

The material on which the present paper is based falls into two categories. The first consists of a series of alizarian-stained (but not cleared) specimens dissected especially in connection with the present work. The specimens in this category are: Serranidae, *Cephalopholis urodelus*, 73 mm in standard length; Apogonidae, *Apogon snyderi*, 95 mm; Mullidae, *Mulloidichthys samoensis*, 87 mm; Carangidae, *Caranx melampygus*, 94 mm; Labridae, *Cheilio inermis*, 85 mm; Embiotocidae, *Damalichthys vacca*, 91 mm; Polynemidae, *Polydactylus sexfilis*, 104 mm; Sphyraenidae, *Sphyraena barracuda*, 110 mm; Atherinidae, *Pranesus insularum*, 75 mm; and Monacanthidae, *Pervagor spilosoma*, 84 mm. The second category, which includes all other fishes mentioned in the paper, is based on specimens in the skeleton collection of the University of Hawaii. At the present time it would often be impossible to determine the length of the specimens in this category; all that can be said is that skeletons were almost invariably prepared from large individuals of the species represented.

Among the beryciform caudal skeletons that have been examined (Gosline, In Press), various permutations of caudal structure are known. Nevertheless, in the Beryciformes there never seem to be more than two independent ossifications in the adult urostyle, more than two uroneurals, or more than six separate hypurals.

The most primitive type of caudal skeleton yet found in the perciform fishes would seem to be that occurring in *Kuhlia sandvicensis* (Fig. 1). In such a skeleton, the primary difference from the beryciform type, aside from the reduction from 17 to 15 branched caudal rays, is that there is only a single urostylar ossification.

The caudal structure found in *Kuhlia, Chaetodon, Polydactylus*, etc. may be defined as follows: (a) 15 branched caudal rays; (b) 3 epurals; (c) 2 independent uroneural ossifications (each uroneural is actually a paired element); (d) urostyle with a single ossification; (e) 6 independent hypurals; and (f) hemal arches of the two vertebrae ahead of the urostylar vertebra separate from their centra, i.e., autogenous.

In a caudal skeleton of this sort the nomenclature of the various elements provides no great difficulty, for such fusions as have already occurred in the evolution of the perciform caudal type would seem to have been between elements within the same series. (The anterior uroneural may be an exception as it probably represents the fusion of neural arch material with strut-like elements of possibly quite different origin.) Thus, the urostyle, which in *Kuhlia* represents the classic structure of this name, is formed by the fusion of several centra. (When, however, the term urostyle is applied to any terminal vertebra with an upturned tip without inquiring whether this upturned tip is made up of centrum elements or uroneurals or both, then the name urostyle loses its significance so far as any study of caudal structure is concerned. In work on vertebral number, it is generally useful to designate the last articulated vertebra in some way; the author would suggest the substitution of some general term like "terminal half-vertebra" or "urostylar vertebra" for urostyle in such studies.) The definition and numbering of the hypurals has also been the source of some confusion in the literature. So far as the perciform fishes are concerned the hypurals may be fairly easily defined as those elements of the caudal skeleton that articulate or fuse with the posteroventral surface of the urostylar half-vertebra. It has been shown in a

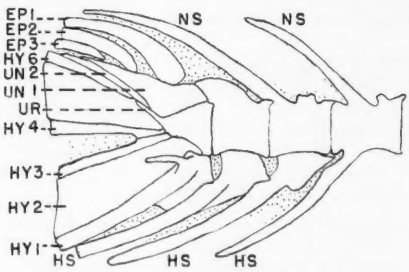

Fig. 1. Caudal skeleton of *Kuhlia sandvicensis*, ×3. Ep, epural; hs, hemal spine; hy, hypural; ns, neural spine; and un, uroneural.

previous paper that the same three hypurals to the lower caudal lobe typically occur throughout the lower modern teleosts, and indeed are the same three that are represented in *Kuhlia*. However, there are five hypurals to the upper caudal lobe in such a fish as *Elops* and the upper of these soon disappear in phylogeny. Consequently, a numbering system for hypurals that starts from the bottom, not the top, is desirable from the point of view of morphological comparison. Nevertheless, wherever a typical "hypural plate" forms by the further fusion of the separate hypurals of *Kuhlia* any numbering system loses much of its morphological significance.

The progressive simplification that takes place in the percoid derivatives seems to be primarily brought about by the fusion of parts, except for the caudal rays where there seems to have been a simple variation in the number of branched elements. Thus the caudal skeletons of such serranids as *Epinephelus* and *Cephalopholis* are very similar to that of *Kuhlia*, but the two separate uroneurals seem to have fused. The caudal skeleton of the grammistid *Pseudogramma* (Gosline, 1960a:34 and fig. 8) approximately duplicates that of *Epinephelus*, but there is a greater number of branched rays in the caudal fin. The caudal skeleton of *Apogon*, however, differs from that of *Epinephelus* chiefly in that the uroneurals have been reduced to two rudimentary ossicles that lie free in the flesh above the urostyle. In general, as the material in this paragraph indicates, the second, i.e., the upper, uroneural of *Kuhlia*, appears to be one of the caudal elements most frequently modified in the higher percoid fishes.

Another trend frequently observed in the percoids is toward the development of a hypural plate. Thus, the lutjanid *Pristipomoides*, though it retains the two separate uroneurals, has hypural 2 fused with 3 and 4 with 5.

Still another line of deviation from the *Kuhlia* type will be followed out in some detail. This is the caudal skeleton of the percesocine groups. The one consistent difference between these forms and all the percoids so far mentioned is that the hemal arch of the antepenultimate vertebra is fused to its centrum (Ford, 1937:45). So far as the caudal skeleton is concerned that of the juvenile barracuda (*Sphyraena barracuda*) 110–115 mm long is an almost complete replicate of that of *Kuhlia*. However, Hollister (1937:275–7, figs. 12–14) has shown that with increasing size there is a progressive fusion of parts in this fish. Thus, a 503 mm individual (Hollister, 1937, fig. 13) shows a partial fusion of the uppermost hypural, i.e., number 6, with the posterior uroneural resulting in a continuous strut that extends forward and down over the tip of the urostyle; also, hypural 2 has fused with 3 and hypural 4 with 5. In a 705 mm specimen (Hollister, 1937, fig. 12), the urostyle has fused with combined hypural 4–5.

Among the remaining families of Percesoces, the caudal skeleton of *Mugil curema* (Hollister, 1937, figs. 8–11) shows the same fusion of the urostyle with hypural 4–5 as occurs in the 750 mm specimen of the barracuda; however in *Mugil curema* this fusion appears to occur early in ontogeny. About the only other notable difference between the caudal skeletons of *Mugil* and *Sphyraena* is the reduction in epural number from 3 to 2. (A Hawaiian specimen of *Mugil cephalus* examined agrees with Hollister's account of *M. curema* in detail.)

In *Atherina harringtoni* (Hollister, 1937: 267–70, figs. 4–7) and in the Hawaiian atherinid *Pranesus insularum*, the caudal skeletons, though somewhat complicated in detail, seem to represent a further consolidation of the *Mugil* condition in that the urostyle, hypurals 4 through 6, and the uroneurals are all ankylosed into a block supporting the upper half of the caudal fin.

To return now to the percoid fishes, the caudal skeleton of the goatfishes *Mulloidichthys* and *Parupeneus* (Fig. 2) is, aside from the autogenous hemal arch on the antepenultimate vertebra, an almost exact duplicate of one phase of percesocine specialization (cf., Hollister, 1937, fig. 12). Thus, the urostyle has fused with combined hypural

4–5; the posterior uroneural is a small triangular bone lying above hypural 6; there are only two epurals, etc. (Dissection demonstrated the paired nature of the uroneural thus eliminating the possibility that it is a rudimentary epural.)

Another series of caudal skeletons include *Zanclus, Acanthurus* and the plectognath fishes. In *Zanclus* and *Acanthurus* almost the same caudal elements are present as in the serranid *Epinephelus*. Thus, there are 6 separate hypurals, 1 uroneural which is separate from the urostyle, 3 epurals, autogenous hemal arches on the antepenultimate and penultimate vertebrae. The only difference would seem to lie in the reduction from 15 to 14 branched caudal rays (7 above and 7 below). The plectognath skeletons available for investigation (i.e., members of the families Balistidae, Monacanthidae, and Tetraodontidae) all have a fused hypural plate, the hemal arch of the antepenultimate vertebra fused to its centrum, and a greatly reduced number of branched caudal rays (e.g., 10 in *Xanthichthys ringens* and *Pervagor spilosoma*).

A final group of fishes to be dealt with includes the pomacentrids, embiotocids, and labroids. In the caudal skeleton of the pomacentrid *Abudefduf abdominalis* (Fig. 3) the fusion is of a somewhat different type than that of any of the perciform fishes hitherto mentioned. The urostyle remains separate from the hypurals but ankyloses instead with the uroneural structures above it. Certain other features may also be noted. Hypural 1 has fused distally with hypural 2, but this is probably due to the fact that the skeleton examined is from a rather large individual. Hypurals 4 and 5 have fused, though hypural 6 (just possibly this is a posterior uroneural) is retained as a small, independent strut. There are three epurals, and the hemal arch

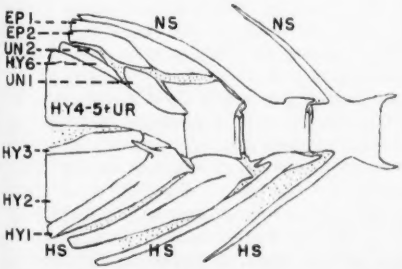

Fig. 2. Caudal skeleton of *Parupeneus porphyreus*, ×2. Lettering as in Fig. 1.

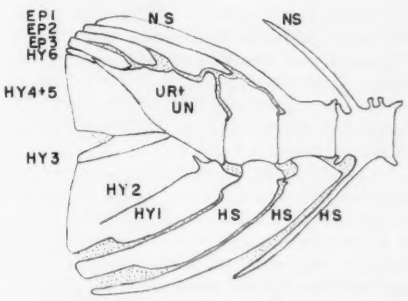

Fig. 3. Caudal skeleton of *Abudefduf abdominalis*, ×3. Lettering as in Fig. 1.

of the antepenultimate vertebra is autogenous. The caudal fin has 13 branched rays, 7 above and 6 below.

The caudal skeleton of the embiotocid *Damalichthys vacca* would seem to differ from that just described for *Abudefduf* in the following respects. Hypurals 1 through 6 are all separate (this contrast with *Abudefduf* may be due in part to the fact that the specimen of *Damalichthys* examined is juvenile, that of *Abudefduf* adult). The hemal arch of the antepenultimate vertebra is fused with its centrum. The caudal fin has 12 branched rays, 6 above and 6 below.

In a young specimen of the labrid *Thalassoma duperreyi*, hypural 2 is fused with 3, and 4 with 5; there are only 2 epurals. As in *Damalichthys* the hemal arch of the antepenultimate vertebra is ankylosed with its centrum and the caudal has 12 branched rays. In Ford's (1937, fig. 14) illustration of the caudal skeleton of *Labrus bergylta*, the urostyle-uroneural complex is fused to the upper hypurals, thus giving a result akin to that shown in the present paper for *Parupeneus* (Fig. 2).

In a large skeleton of *Scarus perspicillatus* the urostyle-uroneural block is united to the bases of hypurals 2–3 and 4–5, thus forming a single continuous supporting element ("hypural plate") for most of the caudal fin. The fin itself has 11 branched rays, 6 above and 5 below.

Discussion and Conclusions

It has not been the objective of this paper to provide a description of all the variants that occur in the caudal skeleton of the perciform fishes; rather it has been to describe the basic pattern in the percoids and to show some of the ways in which this has changed. The author believes that some knowledge of

the basic percoid pattern and its derivatives can make both the description and the interpretation of caudal structure more meaningful in the higher teleosts. With this in mind certain general points about the caudal skeleton in perciform fishes will be discussed here.

In general the evolution of the caudal skeleton in percoid fishes and derivative groups is, as already stated, primarily one of fusion of parts. This fusion progresses over different routes in various groups. However, the endpoint, i.e., a fused hypural plate, is approximately the same in all. For that matter certain halfway points may be the same. Thus a stage such as that occurring in *Atherina* may have been attained first by the fusion of the urostyle and hypural 4–5 with the subsequent incorporation of uroneural elements (as apparently occurred in *Atherina*), or by the fusion of the urostyle and uroneural elements, with subsequent fusion to hypural 4–5 (as has apparently occurred in the Scaridae).

Ontogenetically, beyond the embryonic stages, the caudal skeleton also undergoes a progressive series of fusions. The excellent work of Hollister (1937, etc.) in particular has shown that the types of fusion that occur in the ontogeny of the individual parallel those of the phylogeny of the group. It would seem as if the factors which have led to the fusions in the adults of primitive members of a series have led to the earlier ontogenetic development of the same fusions in more advanced members of the same series. In any event, these ontogenetic fusions must be taken into account when comparing caudal skeletons of different species. (In general, it would seem best to compare caudal skeletons of half-grown individuals, wherever possible.)

If one turns to the question of why the various fusions occur as they do, the first thing that comes to mind is a relationship between structure and function. So far as the caudal structure is concerned very little can be said with regard to functional anatomy. The complexity of the subject is readily illustrated by the fact that the ladyfish (*Elops*), the trout, the pike, and barracuda, and tunas all swim well and rapidly, though they have very different caudal skeletons. It would seem impossible to make any valid generalization with regard to the relationship between swimming speed and caudal skeleton at the present time.

A different potential aspect of functional anatomy will be discussed here. It would seem logical to assume that the progressive fusion of parts of the caudal skeleton would result in increasing rigidity (or decreasing flexibility) within this structure. Thus, in a fish with a fused hypural plate any rotatory motion of the tail would presumably have to be accomplished by the caudal rays alone, whereas in those fishes with a number of independent hypurals a certain amount of the rotation might be carried on by the hypurals. From available data it appears that phylogenetically and ontogenetically the hypurals to the lower caudal lobe and the hemal arch and spine of the penultimate vertebra are the last elements to retain an autogenous (i.e., unfused) attachment to the vertebral column. Thus even when there is a fusion of the urostyle with the uroneural or with hypural 4–5 or both, there would seem to be a certain amount of flexibility possible in the elements of the caudal skeleton to the lower caudal lobe. The retention of such flexibility might also provide an explanation for the autogenous hemal arches on the penultimate and antepenultimate vertebrae.

So much for the hypothesis. What light do available data throw on it? Starting at the antero-ventral portion of the caudal skeleton, most percoids appear to have the hemal arch to the antepenultimate vertebra autogenous. Some groups, e.g., the Percesoces, Pomacentridae, and labroid fishes, do not (although they do retain autogenous hypurals to the lower caudal lobe). If an autogenous junction indicates flexibility and if the lower hypurals remain unfused with the urostyle, then the question arises of why some perciform fishes have the hemal arch of the antepenultimate vertebra autogenous whereas others have it fused with the centrum? The first hypothesis that comes to mind is that, in the fishes in which the antepenultimate hemal arch and centrum are fused, the hemal spine of this vertebra does not reach the caudal base. In each of the species pairs *Polydactylus sexfilis-Mugil cephalus* and *Abudefduf abdominalis-Damalichthys vacca* the first member has the hemal arch on the antepenultimate vertebra autogenous; in the second it is fused to its centrum. However, in all four of these species the hemal spines of the antepenultimate vertebra extend back equally far and end at about the same place under the procurrent rays at the bottom of the caudal fin. With regard to the upper portion of the caudal skeleton, in *Parupeneus* (Fig. 2) the urostyle and hypural 4–5 have fused but the uroneural remains separate,

whereas in *Abudefduf* (Fig. 3) the urostyle and uroneurals have fused, but the upper hypurals have remained separate. Again, the author is at a loss to suggest any functional explanation for these different systems of fusion. Furthermore, the endpoint of a fused hypural plate has been attained in the most varied of groups from pipefishes to tunas. In sum, the author can at present suggest no sound functional explanation for the fusions that occur between any of the elements in the basal percoid caudal skeleton.

However, certain structural correlations have at least been demonstrated. Thus it has been shown (Gosline, 1960b, and In Press) that a rounded tail shape, if continued long enough in the history of the lineage (i.e., longer than in *Epinephelus*, etc.), will have certain predictable effects on caudal structure. The number of branched caudal rays will become variable, etc., etc. In view of this it has seemed worth investigating whether a lunate tail also has an effect on the caudal structure. The well-known reduction in fin ray number in labroid fishes suggests such a possibility. The zanclid-acanthurid-plectognath series and the embiotocid-pomacentrid-labroid groups dealt with in the descriptive part of the paper provide some data on this matter.

By way of introduction it may be stated that a lunate tail is by no means so significant a character as a rounded caudal frequently is. Thus larvae and juveniles of lunate-tailed fishes often have round or truncate tails. Also, there are often adult forms with rounded or truncate tail in groups that typically have a lunate caudal.

Now, the zanclids, acanthurids, labrids, and scarids almost all have a lunate tail in the adults and a reduced number of branched caudal rays (as compared with the typical percoid number of 15). However, the pomacentrids and embiotocids examined, which at least have a caudal skeleton much like that of the labrid genus *Thalassoma*, have forked tails and a reduced number of caudal rays. Again the plectognaths, which are often assumed to be derived from an acanthurid-like fish, usually have rounded tails, but the number of branched caudal rays is even further reduced. Thus there is a possible (probable?) but by no means a close correlation between a lunate tail and a reduction in branched caudal ray number. So far as internal structure is concerned, the caudal skeleton of *Zanclus* and *Acanthurus* duplicates that of the round-tailed basic percoid *Epinephelus*. The labrids seem to be off on a tack of urostyle-uroneural fusion, but this also occurs in the fork-tailed genera *Damalichthys* and *Abudefduf*.

The above paragraphs are not written as an exercise in futility, but rather to demonstrate that the caudal structure does not seem to be directly affected by adaptive radiation. This can consequently be largely ruled out as a possible complication in the use of the caudal skeleton in taxonomy. Several difficulties unfortunately remain. One is that there seems to have been a general trend toward fusion of parts in the caudal skeleton of teleostean fishes that has occurred repeatedly and independently in various lineages. The trend has progressed over at least two different routes (Figs. 2 and 3) in the perciform fishes; nevertheless there is no assurance that a given route has not been travelled several times independently. Furthermore these routes reach the same endpoint, a fused hypural fan, which in itself gives no indication of the sequence of fusions that has been followed and very little regarding taxonomic relationships. Such discouraging factors should not, however, obscure the fact that the caudal skeleton may well prove very useful in helping to determine the relationships of certain perciform groups and their derivatives.

Summary

For certain groups of perciform fishes the caudal skeleton appears to be a good indicator of relationships. This paper attempts to provide information on its possibilities and limitations in this regard. The basal percoid type of caudal skeleton is described and certain lines of morphological divergence from this type are discussed.

Literature Cited

Ford, E. 1937. Vertebral variation in teleostean fishes. *J. Mar. Biol. Assoc. U. K. 22:1–57, Figs. 1–18, Pls. 1–16.*

Gosline, W. A. 1960a. A new Hawaiian percoid fish, *Suttonia lineata*, with a discussion of its relationships and a definition of the family Grammistidae. *Pacific Sci. 14:28–38, Figs. 1–8.*

———. 1960b. Contributions toward a classification of modern isospondylous fishes. *Bull. British Mus. (Nat. Hist.), Zool. 6:327–65, Figs. 1–15.*

———. In Press. Some osteological features of modern lower teleostean fishes.

Hollister, G. 1936. Caudal skeleton of Ber-

muda shallow water fishes. I. Order Isospondyli: Elopidae, Megalopidae, Albulidae, Clupeidae, Dussumieriidae, Engraulidae. *Zoologica 21:257–90. Figs. 1–53.*

———. 1937. Caudal skeleton of Bermuda shallow water fishes. II. Order Percomorphi, Suborder Percesoces: Atherinidae, Mugilidae, Sphyraenidae. *Zoologica 22:265–79, Figs. 1–14.*

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Variations in Anal Fin Ray Count of a Deme of Redside Shiners, *Richardsonius balteatus*, from a Warm Spring

GEORGE F. WEISEL

THE redside shiner, *Richardsonius balteatus*, is one of the commonest minnows in the Pacific Northwest. Its range extends from the Bonneville Basin in Nevada and Utah northward to the Nass and Peace River system in British Columbia and Alberta. The closely related *R. egregius* occurs further south in the Lahonton Basin of Nevada, western Utah, southern Idaho, and northeastern California. The principle difference between the two species is that *R. egregius* has 8–9 anal rays whereas *R. balteatus* has 10–22.

The redside shiner has received considerable attention since the time of Eigenmann (1895) because of the remarkable range in the number of its anal fin rays. Different populations of this species have significantly different means of ray count and fluctuations appear within certain populations. Attempts have been made to correlate these differences with altitude, temperature, latitude, and sex (Eigenmann, 1895a, 1895b; Gilbert and Evermann, 1895; Lindsey, 1953; Weisel, 1955). Each attempted correlation has received contradictory evidence, except one. The exception is that when examined over its entire range, the species is seen to form a cline with the mean number of fin rays progressively increasing northward (Lindsey, 1956).

I have postulated that the south to north increase of anal rays of the redside shiner is genetically rather than environmentally influenced (Weisel, 1955). It may have occurred by intrusion from the north of *R. b. balteatus* upon *R. egregius*. A subspecies with an intermediate number of rays (*R. b. hydrophlox* with 10 to 13 rays) inhabits an area between the two species. Population pockets may exist, especially in headwaters, between the northern and southern limits of the redside shiner which are dominated by either genes for low or for high number of rays. These pockets confuse the picture unless it is observed in its entirety.

To add to the complexity, there is little doubt that environment also plays a part in determining the number of anal rays. These variations of course must be limited by imposed inheritance. The impact of temperature on the rather precise formative periods of meristic characters of fishes has been experimentally demonstrated (Schmidt, 1919; Tåning, 1952; Lindsey, 1954; etc.). However, two investigations attempting to correlate the water temperatures in nature with the number of anal rays of *Richardsonius* obtained opposite results (Lindsey, 1953; Weisel, 1955).

Light is another factor that probably influences the latitudinal gradation in number of meristic characters (McHugh, 1954; Vibert, 1954; Lindsey, 1958). Also it has been suggested by Barsukov (1955) that the variability in the fin rays of single broods of livebearing wolffish is caused by the character of motion the embryo undergoes within its membranes at time of ray formation. The relation of size during development to meristic characters is discussed later.

The present investigation concerns variation in the anal fin ray count of redside shiners from a single deme. Collections were taken in October or November over a nine year period. The deme exists in a warm spring slough, about two acres in extent, which debouches a large head of water directly into the Clarkfork of the Columbia River two miles east of Bearmouth, Montana. These fish are partly isolated. Few shiners inhabit the river and in previous years the river was polluted by wastes from the Anaconda Smelter which at times rendered the river uninhabitable. The slough provides a remarkably constant environment in this

north temperate climate. The warm springs feeding it maintain a temperature of 16° to 17°C., and frequent testing in summer and in subzero weather shows that the slough itself does not vary more than two degrees from this. The water level and flow remain constant. Food also is plentiful throughout the year.

Collections from this deme must be genetically purer and affected less by environmental extremes than collections on which previous studies have been made. In theory this deme should exhibit less variation.

Anal fin rays of 3620 specimens were counted according to the accepted method for cyprinids. The counts were tested for variation in year and size groups. Also specimens from a single year were sexed and analyzed as to number of rays. The statistical tests were applied by the Statistics Laboratory of Montana State University.

Results

Sexual Differences.—In British Columbia Lindsey (1953) detected a difference in number of anal rays between sexes in only a few of the populations he tested. He found in general that there was a trend toward higher female counts in populations having high over-all means, and toward relatively higher male counts in populations with low over-all means.

Six hundred and twenty-two specimens from the 1957 collection were sexed. Fish under 6 cm. in length were excluded as their sex could not be accurately determined under a dissecting microscope. Females were far more numerous than males. In the 6.0 to 7.9 cm. size group, 322 were females and 118 males; in the 8.0 to 9.9 cm. group, 109 were females and 57 males; in the 10.0 to 12.0 group, all were females. The mean number of anal rays for all females was 14.40 and for males was 14.55. When tested statistically, the values indicate no connection between sex and number of anal rays. Fish in the largest size group, all females, had a mean of 15.08, but included only sixteen specimens.

There may be a hidden difference in the number of rays of the sexes. The males apparently have a much higher mortality rate than the females and selection may tend to remove individuals with either high or low counts.

Size Differences.—Variation in number of anal rays of shiners in different size groups has been previously observed (Weisel, 1955). The size groups, though arbitrarily chosen, represent fish hatched in different months of the year and fish of different ages. Consequently, each length class is probably subjected to a somewhat different environment during formation of the rays. This is true for warm spring fish where the environment is relatively stable as well as for populations from more fluctuating environments.

Specimens collected from the warm spring slough in 1949–57 were divided into length groups with 2 cm. increments. The length groups only roughly approximate the ages of the fish. Some aging was done by the scale method, but there was much overlap of lengths in successive year classes. Length frequencies plotted for the large 1957 collection showed no interpretable distribution. This must be owing to the protracted breeding season of the population which extends from the last of March into June. A juvenile only 23 mm. in total length was collected on November 26. Of the specimens aged, the majority in their fourth year and all in their fifth year were females.

There is a significant relation between size and number of anal rays (Table 1). The trend is for larger fish to have higher counts. Non-parametric regression techniques (Dixon and Massey, 1957:297) show this relation can be partly attributed to a trend toward higher counts in larger fish. Analysis of variance shows a significant difference between means ($F = 5.782$, 4 and 3607 degrees of freedom). It appears that fish with the extremes in low ray count tend to be eliminated. Curves of distribution show a skewing toward fewer rays in the smaller groups and toward more rays in the larger fish.

Table 1. Anal Fin Ray Counts for Different Size Groups of the Redside Shiner, *Richardsonius balteatus*

Data are from 3620 specimens collected from 1949–57. For statistical treatment, the two largest size groups were lumped together. $x^2 = 35.2$ with 12 degrees of freedom. The probability that $x^2 > 28.3$ is .005.

Size group (total length in cm.)	Number specimens	Number of fin rays					Range	Mean
		12-13	14	15	16	17-18		
2.0–3.9	472	59	197	167	44	5	12–17	14.43
4.0–5.9	1308	167	527	456	146	12	12–18	14.45
6.0–7.9	1437	119	599	529	160	30	12–18	14.56
8.0–9.9	371	26	142	152	46	5	13–17	14.62
10.0–12.0	32		12	13	6	1	14–17	14.87

Specimens collected in the years 1955, 1956, and 1957 were analyzed separately for size and anal fin ray number. The results cast some doubt on the significance obtained from lumping the collections together. The various size groups of the 1955 and 1956 collections exhibit no statistical difference in ray number, although the mean of the larger fish is slightly the highest. The 1957 specimens show significant differences but no gradation of increase of ray number with increase in size. The next to largest size group has the lowest mean (13.5) and the largest group has the highest mean (15.0).

Fish of the year from the 1957 collection were also subjected to examination. There was no correlation between size and number of rays in these yearlings.

Yearly Differences.—Mean anal ray count of shiners from one locality are known to vary significantly from year to year (Lindsey, 1953; Weisel, 1955). In the warm spring deme there is also a significant difference in distribution of anal ray counts for different years (Table 2). The highest mean is in 1952, and the lowest are in 1949 and 1957. Intermediate means occur between the years of lowest and highest means. This gradation can in part be attributed to the fact that collections from a single year include several year classes from previous years.

As a correlation of size and ray number was discovered, it was thought that perhaps the yearly differences may be owing to differences in the sizes of the fish collected. An analysis of the sizes collected in the various years shows a highly significant difference. In 1952 for example, which had the highest mean ray count, the collection includes mostly large fish.

By random selection, the fish were corrected for size in five of the yearly collections. Analysis of variance of the means of these collections shows $F = 4.61$ with 4 and 1040 degrees of freedom. This indicates a difference between years which cannot be attributed to size differences.

Since a size group roughly reflects the age of the fish, it would be expected that different size groups in a single year's collection would also exhibit differences. As stated above, no differences were found in fish from two of the three years studied. Perhaps the size groups do not jibe closely enough with the year classes.

Size groups with exceptionally high or low means projected back in years by successively taking the next smaller size group show no correlation. Also there is no correlation between ray number and yearly air temperatures during months of greatest spawning activity.

Discussion and Conclusions

Anal rays of *Richardsonius balteatus balteatus* collected over a nine year period from a single deme living in a comparatively stable environment exhibit slight but apparently significant variations. No sexual differences appear to be present, but there are detectable differences in size and year classes.

However, as expected, the variations and fluctuations within the deme are not as pronounced as among different populations. In

Table 2. Anal Fin Ray Counts for Different Years of Collection of the Redside Shiner, *Richardsonius balteatus*

Data are from 3620 specimens collected from 1949–57. The Chi-square test for independence in contingency tables is used here (Cramér, 1946). The observed and expected frequencies are listed below the number of rays with the latter in parentheses. $x^2 = 67.9$ with 21 degrees of freedom. The probability that $x^2 > 41.4$ is .005.

Year collected	Number of fin rays				Mean number of fin rays
	12–13	14	15	16, 17, 18	
1949	9 (4.9)	20 (19.6)	13 (17.5)	6 (6.0)	14.29
1950	24 (32.7)	127 (130.3)	130 (116.2)	38 (39.8)	14.57
1951	37 (32.7)	110 (129.5)	124 (115.5)	46 (39.5)	14.56
1952	7 (21.1)	78 (84.1)	80 (75.0)	41 (25.7)	14.78
1953	17 (28.7)	111 (114.4)	114 (102.0)	38 (34.9)	14.62
1955	51 (56.5)	216 (225.1)	209 (200.7)	75 (68.7)	14.56
1956	99 (88.4)	337 (352.1)	320 (313.9)	110 (111.5)	14.51
1957	127 (106.0)	478 (421.9)	327 (376.2)	101 (128.8)	14.39

the deme the range in means for different years is 14.29 to 14.78 and for size groups is 14.43 to 14.87. Samples taken in a single year from eight other locailties in the same local drainage have a range of 13.77 to 16.09. In British Columbia the mean anal ray count varied from 12.06 to 17.51 (Lindsey, 1953). The greater range among these populations is undoubtedly not entirely owed to their inheritance. They come from diverse environments which induce greater phenotypic variability and are more rigid in selection.

Evidence has accumulated that larger fish within a year class have the higher number of meristic characters, particularly vertebrae (Dannevig, 1933; Tester, 1937; Gosline, 1947). Even in single broods of *Gasterosteus aculeatus* developing under identical experimental conditions, the faster growing individuals develop the most lateral plates (Heuts, 1944). This also appears true for the anal rays of the redside shiner as Lindsey (1953) reports that the larger fry have higher counts.

Young of the year from my collection show no correlation between size and number of anal rays, but this can be expected as the deme has such a protracted spawning period. The major difference in size within a single year class must be largely caused by date of hatching rather than size in the embryonic or prolarval stages. In populations from environments with more fluctuating temperatures, larger fish perhaps come from eggs laid early in the season and the cooler conditions may enhance the expression of more rays (Tåning, 1952; etc.).

On the other hand, a relation between growth rate and number of meristic characters may explain much of the variation found in the warm spring deme. Hubbs (1926) suggested that if a fish reaches a relatively large size before differentiation commences, there will be more space available for the developing serial parts which will allow the expression of higher numbers. He stated further that fishes developing from eggs with an unusually large amount of yolk exhibit a great increase in segment number. This he attributes to retardation of development.

It is my opinion that the size attained by an embryo or larva may be determined by a number of circumstances other than heridity or extrinsic environment. If Hubbs' hypothesis is true, this can lead to considerable variability in meristic characters even in a small interbreeding population residing in a stable environment. For instance the size of the egg must influence the size of the embryo and the larva. Freshly fertilized eggs from a single shiner vary from 1.9 to 2.2 mm. in diameter. This can in part be caused by chance supply of blood to the developing ovum. Eggs produced by a single female early or late in the season are frequently smaller than those produced at the height of the spawning season, and eggs of younger fish are frequently smaller than those of larger females.

Size must also be influenced by chance in first securing food during the postlarval period. Although the time of determination of anal rays in *Richardsonius* is not known, the rays do not become visible until the postlarvae are about 11 mm. long and 22 days old (Weisel and Newman, 1951).

Relation of ray count and size in the developmental period may account for variability, but does not necessarily explain the increasing mean of ray number with increase of size of the lumped year classes. This is probably caused by selectivity—those fish with 12 or 13 rays tend to become eliminated. Inasmuch as the majority of the larger specimens are females, this might appear to be a sexual difference, but the younger females have about the same percentage with low count as the males.

Collections made in different years also differ slightly in number of rays although each collection represents several year classes. It is felt that these differences may be environmentally induced, or that they may be a reflection of imperfect sampling.

Lindsey (1958) found that duration of light during the development of kokanee salmon influences the number of vertebrae and probably the number of anal rays. Sixteen hours of daily light exposure produced lower counts than eight hours. The duration of light may account for latitudinal clines in the redside shiner. Another possibility is that annual differences in cloud cover may be responsible for variability in ray count in the warm spring deme.

As for the sampling, even though the collections are fairly large ones, the chances that they do not represent a random sample must not be ruled out. Like many fishes, shiners of a size and often of a brood tend to school together and hence to be collected together. A considerable portion of a large collection may be composed of fish that chanced to come from either fast or slow growing hatches. Collections may also be made before or after selection has weeded out individuals that are less adaptable. Slight

differences caused by environment, heredity, sex, or chance of size in the developmental stage may supplement each other so as to render an apparent difference; or if in opposition, may cancel a difference.

Inasmuch as variation and fluctuation can be statistically demonstrated within a deme from a relatively stable environment, caution should be taken in comparing different populations. The populations must be adequately sampled not only in numbers but in time and place.

Summary

Anal fin rays of *Richardsonius balteatus* collected over a nine year period from a single deme living in a comparatively stable environment exhibit slight but statistically significant variations. No sexual differences appear to be present, but there are detectable differences in size and year classes. These variations are attributed to selection, environment, and sampling. However, the variations and fluctuations within the deme are not as pronounced as in comparisons between different populations.

Literature Cited

Barsukov, V. V. 1955. On the variability in numbers of rays in the fins of the striped wolffish (*Anarrhichas lupus lupus* L.). *Proc. Acad. Sci. USSR 103:715–6.*

Cramér, H. 1946. Mathematical methods of statistics. Princeton, Princeton Univ. Press, 575 p.

Dannevig, A. 1933. The number of vertebrae in *Gadus virens* L. from the Norwegian Skagerak coast. *J. du Conseil 8:355–6.*

Dixon, W. J. and F. J. Massey, Jr. 1957. Introduction to statistical analysis. *Second edit., McGraw-Hill, New York.*

Eigenmann, C. H. 1895a. Results of explorations in western Canada and northwestern United States. *Bull. U. S. Fish. Comm. 14(1894): 101–32.*

———. 1895b. *Leuciscus balteatus* (Richardson), a study in variation. *Am. Nat. 29:10–25.*

Gilbert, C. H. and B. W. Evermann. 1895. A report upon investigations of the Columbia River basin, with descriptions of four new species of fishes. *Bull. U. S. Fish. Comm. 14(1894): 169–208.*

Gosline, W. A. 1947. Some meristic characters in a population of the fish *Poecilichthys exilis*; their variation and correlation. *Occ. Pap. Mus. Zool. Univ. Mich. 500:1–23.*

Heuts, M. J. 1944. Laterale Bepantsering en Groei bij *Gasterosteus aculeatus*. II. *Natuurwet. Tijdschr. 26:40–52.*

Hubbs, C. L. 1926. The structural consequences of modification of the developmental rate in fishes, considered in reference to certain problems of evolution. *Am. Nat. 60:57–81.*

Lindsey, C. C. 1953. Variation in anal fin ray count of the redside shiner *Richardsonius balteatus* (Richardson). *Canadian J. Zool. 31:211–25.*

———. 1954. Temperature-controlled meristic variation in Paradise fish *Macropodus opercularis* (L.). *Ibid. 32:87–98.*

———. 1956. Distribution and taxonomy of fishes in the Meckenzie drainage of British Columbia. *J. Fish. Res. Bd. Canada. 13:759–89.*

———. 1958. Modification of meristic characters by light duration in kokanee, *Oncorhynchus merka*. *Copeia 1958(2):134–6.*

McHugh, J. L. 1954. The influence of light on the number of vertebrae in the grunion, *Leuresthes tenuis*. *Copeia 1954(1):23–5.*

Schmidt, J. 1919. Racial studies in fishes. II. Experimental investigations with *Lebistes reticulatus* (Peters) Regan. *J. Genetics 3:147–53.*

Tåning, Å. V. 1952. Experimental study of meristic characters in fishes. *Biol. Rev. 27:169–93.*

Tester, A. L. 1937. Populations of herring (*Clupea pallasii*) in the coastal waters of British Columbia. *J. Biol. Bd. Canada 3:108–44.*

Vibert, R. 1954. Effect of solar radiation and of gravel cover on development, growth, and loss in salmon and trout. *Trans. Am. Fish. Soc. 83:194–201.*

Weisel, G. F. and H. W. Newman. 1951. Breeding habits, development and early life history of *Richardsonius balteatus*, a northwestern minnow. *Copeia 1951(3):187–94.*

———. 1955. Variations in the number of fin rays of two cyprinid fishes correlated with natural water temperatures. *Ecology 36:1–6.*

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The Distribution of Eyed Flounder and Lanternfish Larvae in the Georges Bank Area

John B. Colton, Jr.

Considering its proximity to the Gulf Stream, one of the most unusual oceanographic features of the Georges Bank area is that it is so little subject to tropical influences, either in the physical character of its water or in its fauna or flora. Normally,

the distribution of density imposes an impassible barrier to surface drift from the southward and it is only under exceptional conditions, i.e., strong and prolonged southerly winds, that any overflow of tropical or "Gulf Stream" water occurs. (For a detailed discussion of the origin and interrelationships of coastal, slope, and Gulf Stream water and the influence of oceanic water on the physical and biological properties of water over the continental shelf, see Bigelow, 1927, Iselin, 1936 and 1939, and McLellan, 1957.) Such a drift of tropical water over Georges Bank was evidenced during September, October, and November 1956 when 129 postlarval specimens of *Bothus ocellatus* (Agassiz) and 561 myctophid postlarvae were collected in 1-meter net and Hardy Plankton Recorder tows in the upper 10 meters of water. These samples were collected on the FWS Charter Vessel M/V *Silver Bay* during cooperative cruises of the United States Fish and Wildlife Service and the Fisheries Research Board of Canada designed to study the early life history of herring in the offshore waters of the Bay of Fundy and the Gulf of Maine (Tibbo, Legaré, Scattergood, and Temple, 1958). The collections represent a more northwesterly record for *Bothus ocellatus* than has been reported previously and demonstrate a marked correlation between the distribution of these tropical fish larvae and the distribution of temperature.

Description of Larvae

The specimens of *Bothus ocellatus* ranged in total length from 4.5 to 42 mm. The identification is based on descriptions of morphological characteristics of this species given by Kyle (1913) and Norman (1934). The asymmetry of the ventral fins, one being short based and supported by the pelvic bone (blind side) and the other (ocular side) being elongate, extending forward to the urophyal,

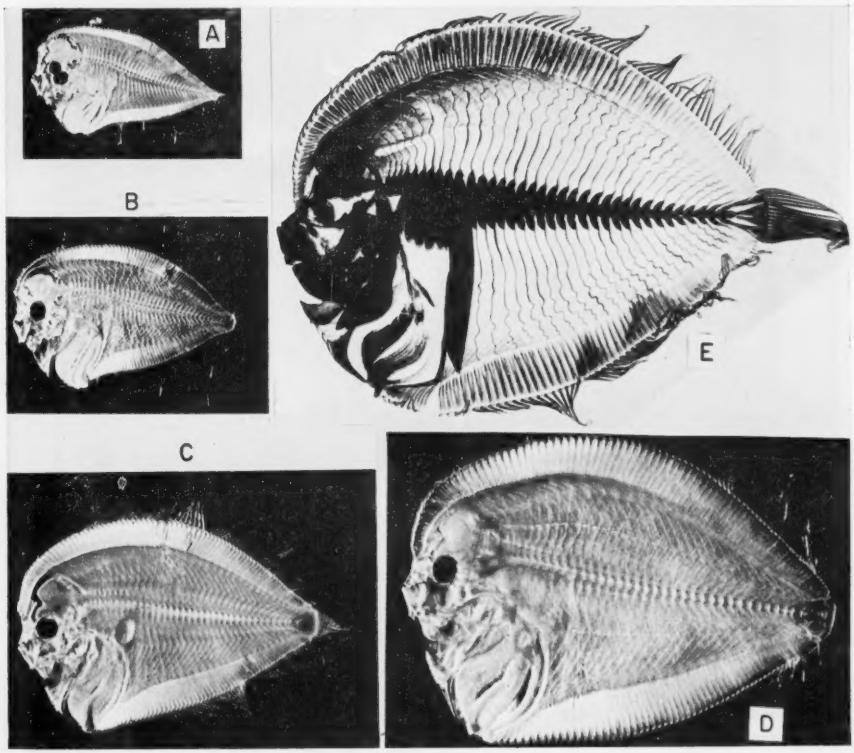

Fig. 1. Postlarval *Bothus ocellatus*, A—6.5 mm., B—8.0 mm., C—11.0 mm., D—15.0 mm., E—19.0 mm.

supported by a cartilaginous plate placed in advance of the cleithra, and with its anterior ray well in advance of the first ray of that on the blind side, places these larvae in the sub-family Bothinae (see Fig. 1 E). *Bothus* is the only genus of the sub-family found on the eastern side of the Atlantic ocean. Dorsal fin ray counts (82–88) and anal fin ray counts (63–65) restrict the species possibilities to *ocellatus, podas* (DeLaroche), and *mellissi* (Norman). Of these three species, only *ocellatus* is found along the Atlantic coast of America.

Kyle (1913) tentatively separated larval and postlarval *Bothus* found west of 35° W. Long. into two species: *B. atlanticus,* having an average of 26 caudal vertebrae and belonging to the Sargasso Sea and mid-Atlantic water further south and only approaching land at the West Indies, and *B. ocellatus,* having an average of 27 caudal vertebrae and occurring along the South American mainland and along the outer edge of the Gulf Stream to the vicinity of the Newfoundland Banks. The total number of vertebrae (atlas through penultimate) in our specimens was 36 (abdominal 10, caudal 26). This number corresponds to that of Kyle's "*atlanticus*" species. Norman (1934), however, concluded that it is improbable that "*atlanticus*" is a species endemic to the Sargasso Sea area and that the majority of *Bothus* larvae captured in the mid-Atlantic are of American origin. He grouped Kyle's two species ("*atlanticus*" and "*ocellatus*") into the one species *Bothus ocellatus.*

Photographs of four cleared and one stained specimen of *Bothus ocellatus* col-

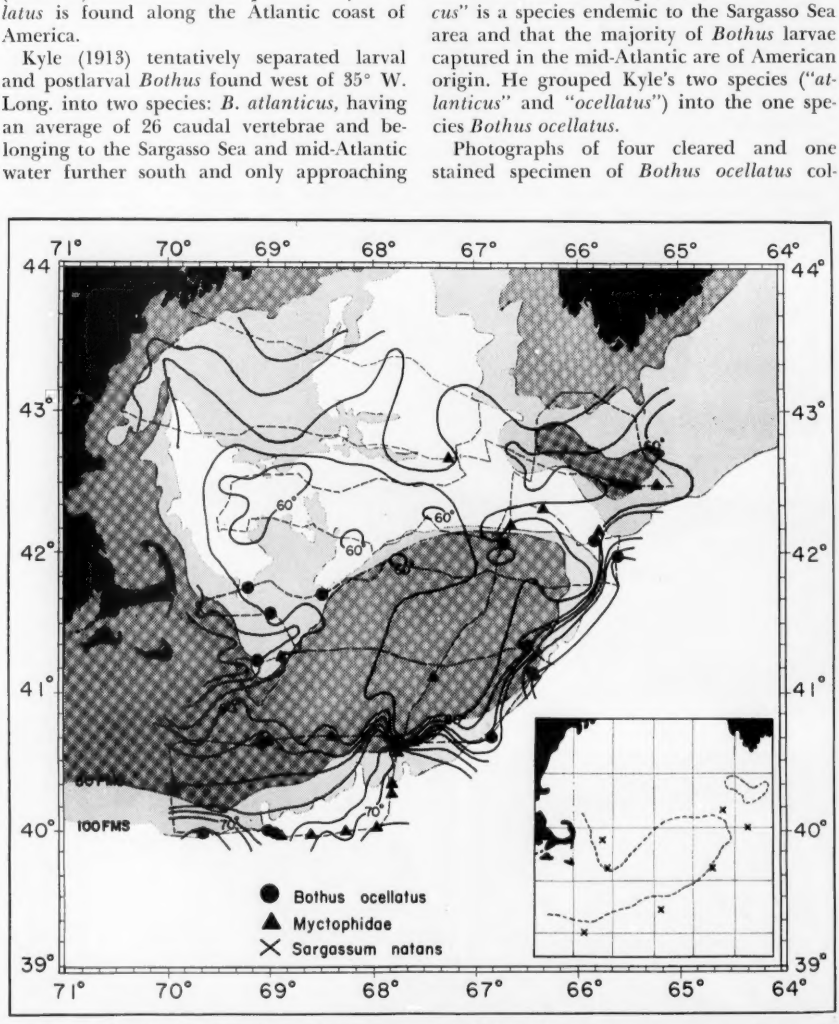

Fig. 2. Distribution of *Bothus ocellatus* and myctophid postlarvae, *Sargassum natans,* and surface temperature, M/V *Silver Bay* Cruise No. 1, September 21–October 5, 1956.

lected in the Georges Bank area are shown in Fig. 1. The eyes of all specimens were still symmetrical, attesting to the long pelagic life of this species. (In *P. bodas*, for example, metamorphosis does not take place until the larvae have reached a length of 30 to 40 mm. (Kyle, 1913).) The general characteristics of the larvae correspond closely to those of specimens of *B. podas* pictured by Kyle (1913:97–8, figs. 13–15). The absence of pigment in any of the larvae was possibly due, as suggested by Kyle, to the reaction to formalin. The dorsal tentacle, which was cleft in our preserved specimens, had disappeared in larvae 8–10 mm. in length which corresponds to the length at which the dorsal tentacle disappears in *B. podas*.

The myctophid postlarvae ranged in total length from 4.5 to 20.0 mm. The incomplete literature on the larval stages of the Myctophidae makes positive identification of these larvae impossible at this time. The most distinctive external characteristics of these larvae are their large eyes, wide mouth, the location of the vent about midway of the body, a deeply forked tail, a black pigment patch over the vent, a dorsal and ventral bar of pigment spots just anterior to the caudal fin, and four pigmented photophores, one at the base of each pectoral and ventral fin.

Distribution

The distribution of *Bothus* and myctophid postlarvae and of surface temperature during September, October, and November is shown in Fig. 2, 3, and 4. The area of occurrence of *Bothus* and myctophid postlarvae during each month was similar, with neither

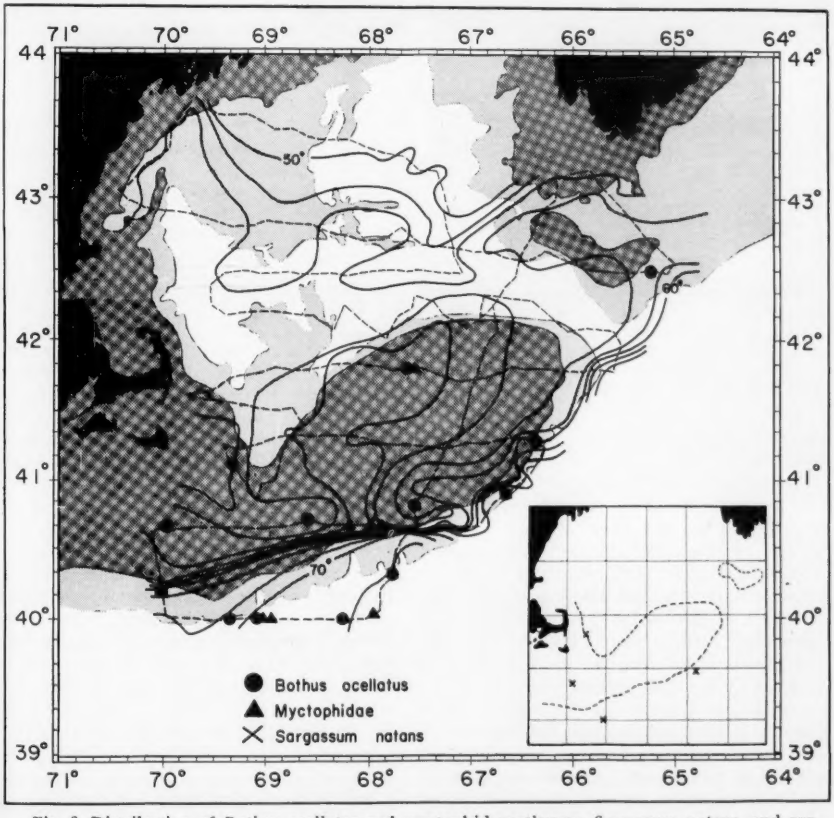

Fig. 3. Distribution of *Bothus ocellatus* and myctophid postlarvae, *Sargassum natans*, and surface temperature, M/V *Silver Bay* Cruise No. 2, October 15–25, 1956.

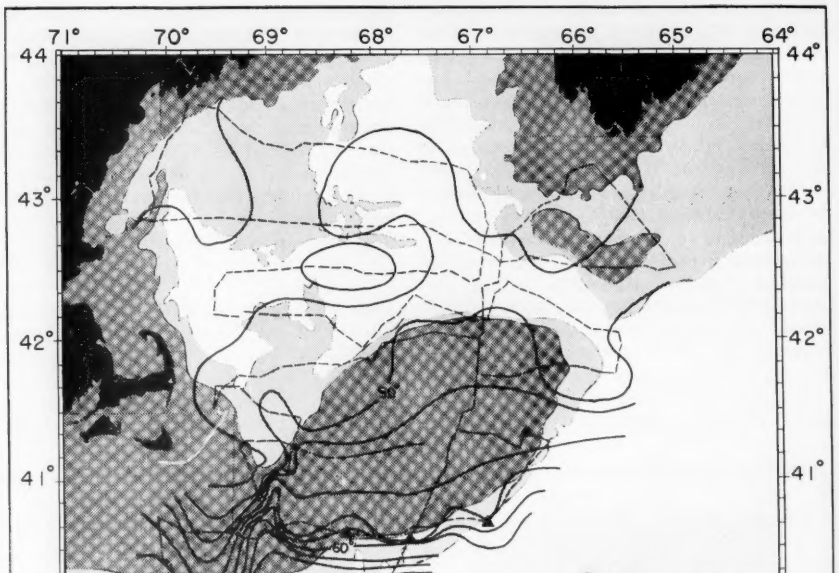

Fig. 4. Distribution of *Bothus ocellatus* and myctophid postlarvae, and surface temperature, M/V *Silver Bay* Cruise No. 4, November 14–30, 1956.

species being present in water much colder than 58°F. During September the surface water over Georges Bank and Browns Bank and over the southern part of the Gulf of Maine was warmer than 58°. In October surface water warmer than 58° occurred only over the eastern and southern edge of Georges Bank, Georges Shoals, and the southern part of the Great South Channel. In November surface water warmer than 58° was present only along the southern edge of Georges Bank. The southerly shift and decrease in areal extent of the warm surface water coincided with a similar change in the distribution of both *Bothus* and myctophid postlarvae. By December surface temperatures over the whole area had fallen below 58° and no *Bothus* or myctophid postlarvae were found. It would appear that these two species are unable to survive in water much colder than 58°F.

Discussion

Wind conditions during late August and early September, as deduced from daily observations at the Georges Shoal Texas Tower, were not unusual for this time of year. Also, the surface temperatures over Georges Bank during the fall of 1956 were not exceptionally high and are not an indication in themselves of an intrusion of tropical water. However the presence of fragments of Gulf weed (*Sargassum natans*) in the meter-net material during September and October is sure evidence of an actual influx of Gulf Stream water. The locations at which *Sargassum* was collected are shown in Fig. 2 and 3. The dis-

tribution of *Sargassum* was similar to that of the *Bothus* and myctophid larvae.

The similarity of the distribution of *S. natans* and of *Bothus* and myctophid postlarvae suggests a common origin. The fact that *S. natans* is native to the Caribbean, an area to which *B. ocellatus* is a common species, indicates that the *Bothus* postlarvae were transported from the latter area by the Gulf Stream system. Such a prolonged journey appears possible, for *Bothus* larvae with the eyes still symmetrical have frequently been collected in the mid-Atlantic (Norman, 1934). The Myctophidae are bathypelagic fish, and collections of them in the north Atlantic have been made principally in the Gulf Stream and in the slope water along the edge of the continental shelf. Only mature specimens of two species of myctophids have been recorded within the Gulf of Maine, the headlight fish, *Diaphus effulgens* (Goode and Bean) and the lanternfish, *Myctophum affine* (Lütken) (Bigelow and Shroeder, 1953). Apparently the myctophid postlarvae were also carried northward by the Gulf Stream system.

That similar instances of an overflow of tropical water onto Georges Bank have not been observed more often may be due in part to the infrequency of coverage of this area during the late summer and early fall when winds are predominantly southwesterly and temperatures over Georges Bank are at a maximum, both conditions being conducive to a breakdown of the normal density barriers existing between coastal and oceanic water. Because existing hydrographic conditions may not indicate that such an overflow has occurred, indicator species are of great value in detecting such phenomena. Subsequent observations during the fall of the year may demonstrate a more frequent intrusion of tropical water over Georges Bank than has been suspected heretofore.

Acknowledgments.—I wish to express my appreciation to Mr. Jack W. Gehringer, Bureau of Commercial Fisheries Biological Laboratory, Brunswick, Georgia and to Dr. Robert H. Gibbs, Jr., Department of Biology, Boston University for examining specimens of myctophid larvae and to Mr. Lynn C. Wall of the Eastman Kodak Company for the photographs of the larval specimens.

Literature Cited

Bigelow, Henry B. 1927. Physical oceanography of the Gulf of Maine. *Bull. U. S. Bur. Fish. 40(2):511–1027.*

Bigelow, Henry B., and William C. Schroeder. 1953. Fishes of the Gulf of Maine. *U. S. Fish and Wildl. Serv. Fish. Bull. 74:1–577.*

Iselin, C. O'D. 1936. A study of the circulation of the western North Atlantic. *Pap. in Phys. Oceanogr. and Meteor. 4(4):1–101.*

———. 1939. Some physical factors which may influence productivity of new England's coastal waters. *J. Mar. Res. 2(1):74–85.*

Kyle, H. M. 1913. Flat-fishes (Heterosomata). *Rep. Danish Ocean. Exped. 1908–10, II, A. 1, 150 pp. 4 pls.*

McLellan, H. J. 1957. On the distinctness and origin of the slope water off the Scotian Shelf and its easterly flow south of the Grand Banks. *J. Fish. Res. Bd. Canada, 14(2):213–39.*

Norman, J. R. 1934. A systematic monograph of the flatfishes (Heterosomata), Vol. I— Psettodidae, Bothidae, Pleuronectidae. *British Museum, London, viii + 459 pp.*

Tibbo, S. N., J. E. Henri Legaré, Leslie W. Scattergood, and R. F. Temple. 1958. On the occurrence and distribution of larval herring (*Clupea harengus*) in the Bay of Fundy and the Gulf of Maine. *J. Fish Res. Bd. Canada, 15(6):1451–69.*

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Variation in the Occurrence of Coronal Spines in *Sebastodes auriculatus* (Girard)[1]

Charles R. Hitz and Allan C. DeLacy

Variation in the occurrence of coronal spines (median frontal) in the brown rockfish, *Sebastodes auriculatus*, has presented difficulties in the accurate identification of this species. Most keys to the genus use coronal spines in some way to differentiate *S. auriculatus* from other members of the *Sebastodes* group. The keys can be di-

[1] Contribution No. 103, College of Fisheries, University of Washington. This study was partially supported by State of Washington Initiative 171 funds for research in biology and medicine. The authors wish to express their appreciation to Dr. D. G. Chapman of the University of Washington for his assistance and advice on statistics.

TABLE 1. SYNONYMS OF *Sebastodes auriculatus* (GIRARD 1858)

Synonym	Author
S. ruber (Ayres 1854)	Cramer (1895)
S. dalli (Eigenmann & Beeson 1894)	Cramer (1895)
S. dalli (Eigenmann & Beeson 1894)	Evermann & Goldsborough (1907)
S. dallii (Eigenmann & Beeson 1894)	Jordan, Evermann & Clark (1930)
S. dallii (Eigenmann & Beeson 1894)	Clemens & Wilby (1946)
S. dalli (Eigenmann & Beeson 1894)	Sunde & Lindsey (1958)
S. auriculatus dalli Jordan & Starks 1895	Jordan & Starks (1895) questioned the validity of their own subspecies description
S. auriculatus dalli Jordan & Starks 1895	Jordan & Evermann (1898)
S. auriculatus dalli Jordan & Starks 1895	Kincaid (1919)
S. auriculatus dalli Jordan & Starks 1895	Hubbs & Schultz (1933)
S. alexandri Evermann & Goldsborough	Hubbs & Schultz (1933)

TABLE 2. FREQUENCIES OF *Sebastodes auriculatus* WITH TWO, ONE AND ZERO SPINES

Trip #	Date	Females				Males			
		Two	One	Zero	Total	Two	One	Zero	Total
1	12/11/59	33	24	18	75	44	15	9	68
2	2/3/60	23	19	12	54	23	15	18	56
3	2/24/60	43	23	20	86	35	13	14	62
4	3/2/60	5	1	1	7	4	5	1	10
5	3/22/60	23	6	5	34	28	4	6	38
6	4/7/60	24	7	14	45	16	10	4	30
7	4/13/60	27	9	12	48	27	15	22	64
8	4/20/60	21	9	11	41	20	11	2	33
Total		199	98	93	390	197	88	76	361

vided into three groups: those that use the presence of coronal spines for identification of *S. auriculatus* (Alverson and Welander, 1952; Phillips, 1957; and Wilimovsky, 1958); those that indicate the presence of coronal spines but note variability and possible absence of the spines (Schultz, 1931; Barnhart, 1936); and those that group *S. auriculatus* with species of *Sebastodes* having the coronal spines absent (Clemens and Wilby, 1946; Sunde and Lindsey, 1958).

Variation in the presence or absence of coronal spines of *S. auriculatus* taken from Puget Sound waters has been reported by Jordan and Gilbert (1882), Jordan and Starks (1895), Jordan and Evermann (1898), Evermann and Goldsborough (1907), and Hubbs and Schultz (1933). It seems to have been partially responsible for the erection of a number of synonyms for *S. auriculatus* in the literature (Table 1).

In the course of an investigation of the early life history of several species of *Sebastodes* the authors have had an opportunity to observe the variation in the coronal spines of *S. auriculatus*. Variation of spine development by size and by sex has been given particular attention.

Samples of *S. auriculatus* were taken from the Port Orchard area of Puget Sound, Washington with an otter trawl fished by the College of Fisheries research vessel *Commando* on eight trips during 1959 and 1960. For all trips, date, time of haul, total length, sex, and

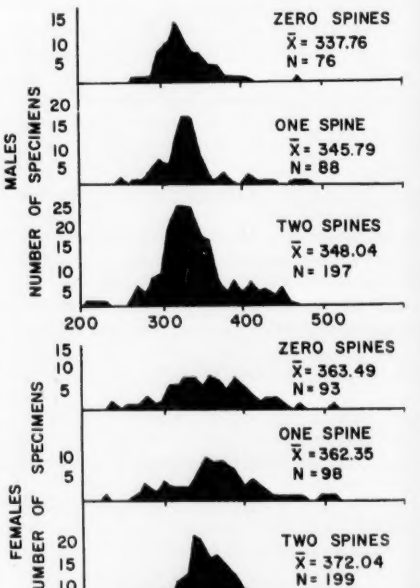

Fig. 1. Length frequencies of male and female *Sebastodes auriculatus* with two, one and zero coronal spines.

number of coronal spines were recorded by the same individual.

The frequencies of *S. auriculatus* having two, one, or zero coronal spines are tabulated by sex and trip in Table 2. Between-trip variability in the occurrence of coronal spines by sex was tested by the chi-square method. For the females a value of 14.225 with 12 degrees of freedom (trip 4 grouped with 5) was obtained, which is not significant at the 5 percent level. Females for all trips were therefore grouped for further treatment of the data. Males similarly treated gave a chi-square value of 25.850—a significant value at the 5 percent level but not at the 1 percent level. The between-trip variability of spines for the males was considered borderline. However, for the purpose of this study, all trips were combined for further data treatment.

TABLE 3. TABULATED LENGTH FREQUENCIES OF MALE AND FEMALE *Sebastodes auriculatus* WITH TWO, ONE AND ZERO CORONAL SPINES

Total Length mm.	Females				Males				Grand Total
	Two	One	Zero	Total	Two	One	Zero	Total	
215	—	1	—	1	1	—	—	1	2
225	—	1	—	1	1	—	—	1	2
235	2	2	—	4	1	—	—	1	5
245	1	—	2	3	—	1	—	1	4
255	2	—	—	2	—	—	—	—	2
265	2	1	1	4	—	—	—	—	4
275	3	2	1	6	5	1	1	7	13
285	6	4	3	13	3	—	1	4	17
295	5	1	2	8	7	4	2	13	21
305	6	5	2	13	8	6	7	21	34
315	6	4	6	16	19	5	10	34	50
325	9	3	6	18	25	12	15	52	70
335	11	3	8	22	25	17	11	53	75
345	21	5	8	34	24	17	7	48	82
355	20	11	5	36	18	8	7	33	69
365	15	10	9	34	16	2	5	23	57
375	16	10	7	33	7	1	5	13	46
385	13	9	4	26	4	3	1	8	34
395	11	6	8	25	6	2	1	9	34
405	8	3	6	17	4	—	1	5	22
415	7	5	4	16	6	3	1	10	26
425	5	4	1	10	4	1	—	5	15
435	6	2	3	11	4	1	—	5	16
445	2	1	3	6	3	1	—	4	10
455	2	1	2	5	5	—	—	5	10
465	4	1	—	5	1	1	—	2	7
475	2	1	1	4	—	1	1	2	6
485	1	—	—	1	—	1	—	1	2
495	3	—	—	3	—	—	—	—	3
505	2	1	—	3	—	—	—	—	3
515	3	1	1	5	—	—	—	—	5
525	—	—	—	—	—	—	—	—	—
535	—	—	—	—	—	—	—	—	—
545	2	—	—	2	—	—	—	—	2
555	3	—	—	3	—	—	—	—	3
Total	199	98	93	390	197	88	76	361	751

TABLE 4. ANALYSIS OF VARIANCE (NESTED) TABLE FOR THE HYPOTHESIS THAT THERE IS NO SIGNIFICANT DIFFERENCE IN THE MEAN LENGTH OF *Sebastodes auriculatus* BY SEX OR BY NUMBER OF CORONAL SPINES

Source	Sum of Squares	Degrees of Freedom	Mean Square
Between sexes	92,656	1	92,656
Between spines	14,007	4	3,501
Within samples (each fish, each spine)	1,910,790	745	2,564
Test between spines	F = 1.365 (4 and 745) d.f. Accept at 5% level		
Test between sexes	F = 36.137 (1 and 745) d.f. Reject at 5% level		

By combining the frequencies for all trips the spine variability between sexes was compared using a chi-square test. A chi-square value of 1.146 with 2 degrees of freedom was not significant at the 5 percent level. Since no statistical significance was noted between sexes, males and females were subsequently combined and the percentage occurrence of two, one and zero spines calculated. Of all fish examined 52.80 percent had two spines, 24.67 one spine (right or left) and 22.53 zero spines.

The length frequency distributions by sex for *S. auriculatus* with two, one or zero spines are given in Fig. 1 and Table 3. A (nested or heirarchal) analysis of variance (Snedecor 1957:264) performed for these distributions showed no significant difference between mean lengths of the two, one and zero spine groups, although a significant difference between mean lengths of the sexes existed (Table 4).

SUMMARY

Variation in the number of coronal spines of *Sebastodes auriculatus* has been a problem with taxonomists for a number of years in the Puget Sound area. In one area of Puget Sound it was found to be 53% with two

spines, 25% with one spine (right or left), and 22% zero spines. This variation was not affected by sex or by length of fish.

Literature Cited

Alverson, D. L. and A. D. Welander. 1952. Notes on the scorpaenoid fishes of Washington and adjacent areas, with a key for their identification. *Copeia 1952(3):138–43.*

Barnhart, P. S. 1936. Marine fishes of southern California. *Univ. Calif. Press, Berkeley, Calif., 209 p.*

Clemens, W. A. and G. V. Wilby. 1946. Fishes of the Pacific coast of Canada. *Fish. Res. Bd. Canada, Bull. 68:1–368.*

Cramer, F. 1895. On the cranial characteristics of the genus *Sebastodes*. *U. S. Natl. Mus. Proc. 5(2nd Ser.):573–610.*

Evermann, B. W. and E. L. Goldsborough. 1907. The fishes of Alaska. *U. S. Bur. Fish. Bull. 26: 219–360.*

Hubbs, C. L. and L. P. Schultz. 1933. Descriptions of two new American species referable to the rockfish genus *Sebastodes*, with notes on related species. *Univ. Wash. Publ. Biol. 2(2):15–44.*

Jordan, D. S. and B. W. Evermann. 1898. Fishes of North and Middle America, part 2. *U. S. Natl. Mus. Bull. 47:1241–2183.*

——— and C. H. Gilbert. 1882. The fishes of North America. *U. S. Natl. Mus. Bull. 16:1018.*

——— and E. C. Starks. 1895. The fishes of Puget Sound. *Proc. Calif. Acad. Sci. 5(Ser. 2):785–855.*

———, Evermann, B. W. and H. W. Clark. 1930. Check list of the fishes and fish-like vertebrates of North and Middle America north of the northern boundary of Venezuela and Colombia. *Rept. U. S. Comm. Fish. 1928, Doc. 1055, (2):1–670.*

Kincaid, T. 1919. An annotated list of Puget Sound fishes. *Wash. Dept. Fish. 51 p.*

Phillips, J. B. 1957. A review of the rockfishes of California (Family Scorpaenidae). *Calif. Dept. Fish and Game, Fish. Bull. 104:1–158.*

Schultz, L. P. 1936. Keys to the fishes of Washington, Oregon, and closely adjoining regions. *Univ. Wash. Pub. Biol. 2(4):103–228.*

Snedecor, G. W. 1957. Statistical Methods. *The Iowa State Col. Press, Ames, Iowa: 534 p.*

Sunde, L. A. and C. C. Lindsey. 1958. Revised key to the rockfishes (Scorpaenidae) of British Columbia. *Inst. of Fish. Univ. Brit. Columbia, Mus. Contrib. No. 1:6 p.*

Wilimovsky, N. J. 1958. Provisional keys to the fishes of Alaska. *U. S. Fish and Wildl. Serv., Fish. Research Lab. Juneau, Alaska, May:113 p.*

Exploratory Fishing and Gear Research Base, Bureau of Commercial Fisheries, Seattle, Washington and College of Fisheries, University of Washington.

The Identification of Larval Yellow Perch, *Perca flavescens* and Walleye, *Stizostedion vitreum*

Carroll R. Norden

BIOLOGISTS have long recognized the necessity of correctly identifying the larvae and very young of fishes when they investigate the life history, distribution, spawning success, and even the systematics of a species. In the past, authors have used such characters as location and concentration of pigment (Pritchard, 1930; Fish, 1932; Balinsky, 1948; Winn and Miller, 1954; Mansueti, 1956), myomere counts (Leim, 1924; Fish, 1932), and pre- and postanal measurements (Winn and Miller, 1954) as a means of identifying larval fishes.

The purpose of this study was to present data that could be used to distinguish some of the larval fishes of the Great Lakes; in particular, the walleye, *Stizostedion vitreum* (Mitchill) and the yellow perch, *Perca flavescens* (Mitchill). It was found that the best way to distinguish walleye from yellow perch larvae was the postanal myomere count, the length of the yolk sac, the length of the intestine, the snout-to-anus and anus-to-caudal measurements, and the location of the lower jaw articulation. Pigmentation and chromatophore development, although of some value are quite variable, showing rather conspicuous differences among larvae collected from different bodies of water.

Much of the initial work was done while I was employed by the United States Department of the Interior, Bur. of Commercial Fisheries' Great Lakes Laboratory at Ann Arbor, Michigan during the summers of 1958 and 1959. I wish to thank Mr. John Parsons, Leonard Joeris, Ernest Korvelis, and Dr. Alfred M. Beeton of the Great Lakes Laboratory for their efforts in securing specimens.

Materials and Methods

Approximately 1186 larval and very young yellow perch with a range of 5.4 to 43.3 mm.

in total length (T.L.) and 235 larval and very young walleye 7.4 to 33.5 mm. T. L., were used in the study.

Most of the specimens were collected in the Great Lakes with one-quarter and one-half meter plankton nets of various mesh sizes. These were attached to trawls in conjunction with investigations of the U. S. Fish and Wildlife research vessel *Cisco* in Lake Erie during 1957 and 1958 and the *Musky* in Lake Erie during 1957–59. Larvae were also collected by small trawls towed from outboard motor boats in northern Green Bay, Lake Michigan, and in Sandusky Bay and other areas of western Lake Erie. A few of the walleye larvae came from hatchery stock at Put-in-Bay, Ohio.

The larval fishes were preserved in 10 percent formalin and many were studied in this preservative under a compound binocular microscope. Others were partially cleared in 3 percent KOH so that the internal anatomy was more clearly visible. Samples of various stages were cleared in 3 percent KOH, stained in alizarin red, and preserved in glycerine as prescribed by Evans (1948), in order to determine early centers of ossification.

Measurements were taken with an ocular micrometer, or with calipers under the low-power of a binocular dissecting microscope. The total length is the distance from the anterior tip of the snout to the posterior tip of the caudal finfold or caudal fin. The snout-to-anus measurement is the distance from the anterior tip of the snout to the anus. The anus-to-caudal measurement is the distance from the anus to the posterior tip of the caudal finfold or caudal fin. The intestine length is the distance from the posterior margin of the yolk sac to the anus in the prolarvae, or from the posterior margin of the stomach to the anus in the postlarvae. The length of the yolk sac is the longest anterior-posterior dimension. The preanal myomeres are all those from the nape to the posterior end of the anus. The postanal myomeres are all the remaining myomeres from the anus to the caudal fin.

Following the work of Hubbs (1943), and Winn and Miller (1954), an attempt was made to divide the larvae into two categories: the prolarval stage in which the yolk sac was present, and postlarval stage after the absorption of the yolk sac, until the juvenile characters were attained. Since growth and development proceed so rapidly in these two species it was necessary to subdivide the larvae into one mm. length intervals.

Prolarva

Larval yellow perch (Fig. 1) in this stage of development are from 5.5 to about 7.0 mm. T.L., whereas the walleye prolarvae (Fig. 4) are from 7.4 (Ryder, 1887:519, gives 5.8 mm.) to about 9.6 mm. In both species the notochord is straight and the finfolds are complete. In the yellow perch the dorsal finfold commences at the base of the first myomere and is almost straight to the caudal; in the walleye it commences about the third to the sixth myomere and there is a slight rise posterior to the vent. The ventral finfold of the two species, commences along the posterior margin of the yolk sac, breaks at the anus and then continues to the caudal fin. It is widest just posterior to the anus. Both species have pectoral fin buds but not the pelvics, and such cartilaginous elements as the dentaries, branchial arches, semicircular canals, and cleithra are distinguishable.

The yolk sac of the yellow perch is an ovate structure about 1.1 to 2.3 mm. in length (Table 1) and 0.4 to 0.8 mm. in width, and it becomes smaller as development proceeds so that it is no longer feasible to measure after the larvae are about 6.8 mm. The yolk sac of the walleye is more elongated, about 2.1 to 2.6 mm. in length and about 0.8 to 1.3 mm. in width (Table 1). It too becomes smaller as development proceeds so that it becomes impractical to measure after the larvae have reached a length of 9.4 mm. Both have a clear, round oil globule at the anterior end of the yolk sac. The intestine, from the posterior margin of the yolk sac to the anus, is straight and from 0.5 to 1.1 mm. in length (Table 1) in the yellow perch. It is shorter in the walleye, from 0.3 to 0.7 mm. in length (Table 1) and bends abruptly downward to the anus. The anus-to-caudal measurement of the yellow perch is slightly less than the snout-to-anus measurement whereas in the walleye prolarvae the anus-to-caudal measurement is greater (about 10 percent) than the snout-to-anus measurement (Table 1). The yellow perch has from 17 to 21 (18) preanal and from 17 to 20 (18) postanal myomeres whereas the walleye has 16 to 20 (18) preanal and 25 to 28 (26) postanal myomeres.

Pigmentation is rather sparse in the prolarval yellow perch (Fish, 1932:362). A pair of large, stellate chromatophores appear over the oil globule and from six to ten over the remainder of the yolk sac. One, two, or three large chromatophores are found near the anus and a few smaller ones occur along the

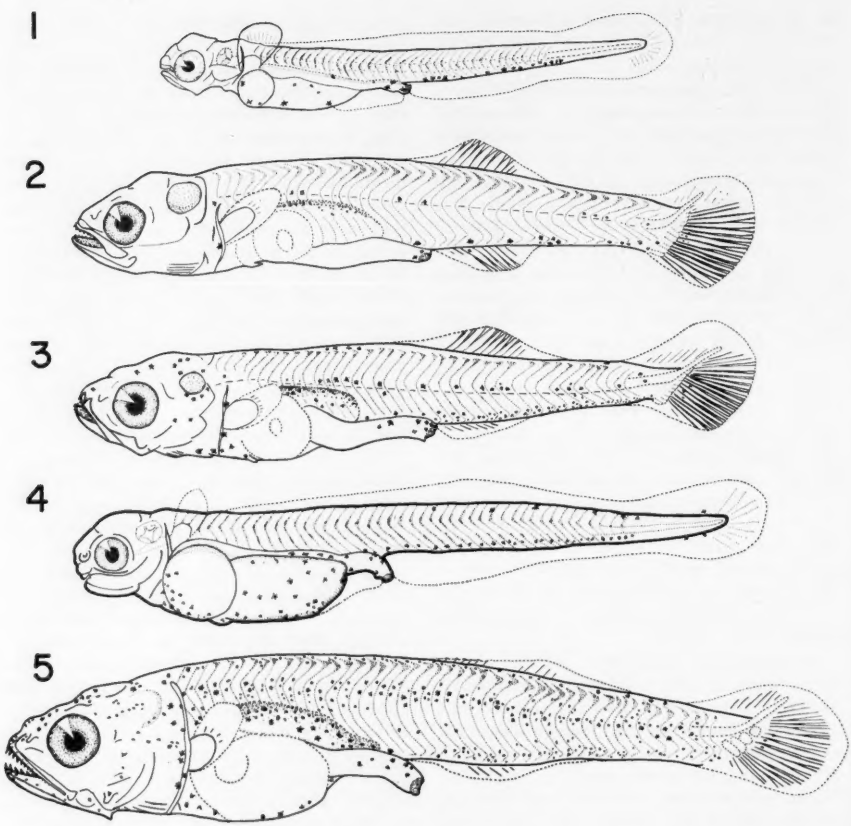

Fig. 1. *Perca flavescens* (Mitchill) Prolarva. Total length = 5.8 mm. Lake Erie. May 14, 1959.
Fig. 2. *Perca flavescens* (Mitchill) Postlarva. Total length = 13.0 mm. Lake Erie. June 6, 1959.
Fig. 3. *Perca flavescens* (Mitchill) Postlarva. Total length = 13.0 mm. Lake Michigan. June 2, 1959.
Fig. 4. *Stizostedion vitreum* (Mitchill) Prolarva. Total length = 8.0 mm. Lake Erie. May 14, 1959.
Fig. 5. *Stizostedion vitreum* (Mitchill) Postlarva. Total length = 14.8 mm. Lake Michigan. June 2, 1959.

dorsal margin of the intestine. A ventral line of 15 to 20 small chromatophores may be seen commencing at the anus and ending near the caudal fin.

Pigmentation in the walleye prolarvae is more profuse. The yolk sac has many small, stellate chromatophores scattered over its lateral and ventral surfaces. From two to four chromatophores are usually present on the intestine between the anus and the yolk sac and occasionally one or two are visible on the lateral margin of the lower jaw. The ventral pigment line, beginning at the anus and extending on to the caudal fin is well developed, with one or more chromatophores per body segment. A few small chromatophores are faintly visible in the visceral pigment line, dorsal to the yolk sac and one or two are present along the dorsal pigment line in the region of the caudal fin.

Postlarva

Yellow perch larvae in this stage of development are from 7.0 to 35.0 mm. in T.L. (Figs. 2 and 3) and the walleye larvae are from 9.5 to about 40.0 mm. long (Fig. 4). The finfolds gradually disappear and are practically gone when both species reach a length of 13.0 mm. Ossified rays first appear in the ventral half of the caudal fin (between 8.0 and 9.0 mm. T.L.) in the yellow perch and at 10.5 mm. in the walleye (Table

TABLE 1. PRINCIPAL CHARACTERS USED TO DISTINGUISH EARLY DEVELOPMENTAL STAGES OF THE YELLOW PERCH FROM THE WALLEYE

Character	Yellow perch, *Perca flavescens*		Walleye, *Stizostedion vitreum*	
	Measurements or Numbers	Number of Specimens	Measurements or Numbers	Number of Specimens
Prolarva				
Total length	5.5–7.0 mm.	42	7.4–9.6 mm.	45
Yolk Sac				
Length	1.1–2.3 mm.	24	2.1–2.6 mm.	21
Width	0.4–0.8 mm.	24	0.8–1.3 mm.	21
Intestine				
Length	0.5–1.1 mm.	35	0.3–0.7 mm.	30
Snout-to-anus	3.0–3.8 mm.	24	3.5–4.5 mm.	26
Anus-to-caudal	2.6–3.5 mm.	24	3.6–5.5 mm.	26
Myomere number				
Preanal	17–21 (18)	42	16–20 (18)	44
Postanal	17–20 (18)	42	25–28 (26)	44
Pigmentation	Ventral pigment line of 15 to 20 small chromatophores. Few on yolk sac.		Ventral pigment line well developed. Numerous chromatophores on ventral surface of yolk sac.	
Postlarva				
Total length	7.0–35.0 mm.	78	9.5–32 mm.	42
Myomere number				
Preanal	17–22 (19)	78	16–24 (19)	42
Postanal	16–21 (19)	78	22–29 (26)	42
Articulation of lower jaw	Below the orbit.		Below posterior margin of orbit.	
Teeth	Small, non-canine.		Larger, with some canine-like.	
Pigmentation	Dorsal, lateral, visceral pigment lines poorly developed. Few chromatophores on top of head, cheeks, and jaws.		Dorsal, lateral, visceral, and ventral pigment lines well developed. Chromatophores abundant on top of head, cheeks, and jaws.	

TABLE 2. TOTAL LENGTH AT WHICH CERTAIN MERISTIC CHARACTERS COMMENCE TO OSSIFY

Character	*Perca flavescens*			*Stizostedion vitreum*		
	Total length Intervals (mm.)	Number of Elements	Number of Specimens	Total length Intervals (mm.)	Number of Elements	Number of Specimens
Caudal fin rays	8.0–8.9	0 to 10	8	10.0–10.9	0 to 11	12
Branchiostegal rays	9.0–9.9	0 to 4	17	10.0–10.9	0 to 4	12
Vertebrae	9.0–9.9	0 to 27	17	12.0–12.9	0 to 23	5
Dorsal fin rays	12.0–12.9	0 to 6	10	13.0–13.9	0 to 11	7
Anal fin rays	12.0–12.9	0 to 3	10	12.0–12.9	0 to 3	5
Pectoral fin rays	13.0–13.9	0 to 5	7	15.0–15.9	0 to 7	3
Dorsal spines	13.0–13.9	0 to 9	7	15.0–15.9	5 to 13	3
Anal spines	13.0–13.9	0 to 2	7	15.0–15.9	1 to 2	3
Pelvic fin rays	15.0–15.9	0 to 4	3	16.0–16.9	0 to 4	2

2). Ossified rays appear in the dorsal and anal fins at about the same time, at 12.0 to 13.0 mm. T.L. in the yellow perch and at 13.0 to 14.0 mm. T.L. in the walleye, although in one specimen three anal fin rays were partially ossified in a larva 12.6 mm. long (Table 2). Pectoral fin rays, dorsal, and anal spines are beginning to ossify when the

TABLE 3. TOTAL LENGTH AT WHICH CERTAIN BONES COMMENCE TO OSSIFY

Bones	*Perca flavescens*			*Stizostedion vitreum*		
	Total Length Intervals (mm.)	Number Examined	Number with Ossification	Total Length Intervals (mm.)	Number Examined	Number with Ossification
Cleithrum	7.0–7.9	16	3	9.0–9.9	9	4
Dentary	7.0–7.9	16	2	9.0–9.9	9	3
Premaxilla	7.0–7.9	16	2	9.0–9.9	9	6
Dentary teeth	7.0–7.9	16	2	9.0–9.9	9	1
Ceratobranchials	7.0–7.9	16	2	9.0–9.9	9	1
Maxilla	8.0–8.9	8	6	10.0–10.9	12	6
Premaxillary teeth	8.0–8.9	8	5	10.0–10.9	12	6
Branchial arches	8.0–8.9	8	2	10.0–10.9	12	10
Quadrate	9.0–9.9	17	1	10.0–10.9	12	2
Frontal	10.0–10.9	19	3	12.0–12.9	5	2
Preopercle	10.0–10.9	19	1	12.0–12.9	5	4
Opercle	10.0–10.9	19	3	12.0–12.9	5	5

larval yellow perch are between 13.0 and 14.0 mm. T.L. whereas these elements commence to ossify between 15.0 and 16.0 mm. T.L. in the walleye larvae. The pelvic fin rays are the last to ossify in both species, at 15.0 to 16.0 mm. T.L. in the yellow perch and at 16.0 to 17.0 mm. in the walleye.

The first bones to show any evidence of ossification (at 7.4 mm. in the yellow perch and at 9.5 mm. in the walleye) are the cleithra, dentaries, premaxillae, and ceratobranchials (Table 3). At 8.3 mm., teeth are visible on the premaxillae and ossification is commencing in the maxillae and branchial arches of the yellow perch. This does not occur in the walleye until they have reached a length of 10.5 mm. However, the qradrates and branchiostegal rays are also ossifying at this stage (Tables 2 and 3). This stage compares favorably with the largest specimen (Fig. 64) illustrated by Reighard (1888). In the yellow perch, these bones (quadrates and branchiostegal rays) as well as the vertebrae commence to ossify when the larvae are between 9.0 and 10.0 mm. T.L. At 10.0 to 11.0 mm. in length the deposition of bone is occurring in the opercle, preopercle, and frontal bones of the yellow perch. The articulation of the partially ossified lower jaw is now clearly visible, it being located below the orbit. The opercle, preopercle, frontal, and vertebrae commence to ossify in the walleye at 12.0 to 13.0 mm. T.L. The articulation of the lower jaw is located below or behind the posterior margin of the orbit (Fig. 5). The deposition of bone is continuous and rapid from this time onward and at 18.0 mm. all bones are in various stages of ossification. In yellow perch larvae, scales first appeared at size intervals of 21.0 to 22.0 mm. In the largest walleye specimen available (33.5 mm.) scales had not yet appeared.

The intestine of the yellow perch is rather elongate, being almost twice the length of the lower jaw. In the walleye, the intestine is somewhat coiled near the stomach but posterior to the stomach it is almost straight to the anus, measuring about 15 percent of the total length of the fish and approximately equal to the length of the lower jaw.

Seventeen to 22 (19) preanal and 16 to 21 (19) postanal myomeres are present in the postlarval yellow perch, whereas 16 to 24 (19) preanal and from 22 to 29 (26) postanal myomeres are present in the walleye. Thus the myomere count is closely correlated with the number of vertebrae as tabulated by Bailey and Gosline (1955:10).

Pigmentation is more profuse in the postlarval walleye and becomes increasingly so with size and age (Reighard, 1888; Fish, 1932). The dorsal pigment line, commencing at the head and continuing to or near the caudal fin, is usually double. One row lies dorsal to the notochord with from one to four chromatophores per myomere while the second row is found along the mid-dorsal region of the body, with one or two chromatophores per segment. The lateral pigment line is well developed in all postlarval stages. These lateral chromatophores, from one to four per myomere, are located in the dermis

at a level with and just below the notochord. The visceral pigment line is very conspicuous with numerous chromatophores located dorsal to and around the air bladder. Chromatophores are also plentiful dorsal to the intestine but decrease in number near the anus, with from two to six present near the vent. The ventral pigment line runs from the anus onto the caudal fin, with one, two, or three chromatophores per segment. Large stellate chromatophores are abundant on top of the head, from the tip of the snout to the nape, on the cheeks, at the base of the pectoral fin and in the region of the heart. In addition, the sides and tips of both jaws are fairly well pigmented.

The concentration of pigment in the postlarval yellow perch gradually increases with age, although less so than in the young walleye. A similar observation was reported by Fish (1932). Pigment characters are difficult to describe in the postlarvae because those collected from Lake Michigan are much darker than those of equal size collected from Lake Erie. There is little difference in chromatophore development in the prolarvae from these two lakes but at size ranges from 12.0 to 18.0 mm. the Lake Michigan postlarvae (Fig. 3) are readily separable from the Lake Erie postlarvae (Fig. 2).

In specimens from Lake Erie, the dorsal pigment line is usually obsolete whereas the Lake Michigan specimens have eight or more widely scattered chromatophores. The lateral pigment line is incompletely developed in larvae from both lakes, although in the Lake Michigan specimens chromatophores are more numerous in the area from the anus to the caudal fin. The visceral pigmentation, dorsal to the air bladder, is very concentrated in specimens from the two lakes, but along the entire length of the intestine there are only one or two chromatophores in the Lake Erie larvae whereas those from Lake Michigan have from two to seven. The ventral pigment line, from the anus to the caudal fin, is well developed in both, but a greater concentration appears on the Lake Michigan specimens, especially on the caudal fin. Six to eight chromatophores are found in the region of the heart in larvae collected from Lake Michigan; those from Lake Erie have only one or two. Chromatophores are more plentiful on the top of the head, on the cheeks, at the tip of the lower jaw and along the pectoral girdle in larvae from Lake Michigan.

This study indicates that pigment characteristics cannot be used to define the postlarvae of the yellow perch with any degree of accuracy and that the larvae of this species differ markedly in the degree of chromatophore development.

Summary

Prolarvae and postlarvae of the yellow perch, *Perca flavescens*, and of the walleye, *Stizostedion vitreum*, can be separated by morphometric and meristic characters, and to a lesser extent by differences in pigmentation. The average number of postanal myomeres in all larvae of yellow perch is about seven less than that found in the walleye at similar stages. The average size of the prolarval yellow perch (5.5–7.0 mm. T.L.) is significantly less than that of the walleye (7.4–9.6 mm. T.L.). There is a similar reduction in the size of the yolk sac in the former species when it is compared with the latter. Other differences include the articulation of the lower jaw which is located below the orbit, the character of the teeth, and the longer intestine in the yellow perch, whereas the articulation of the lower jaw is located below the posterior margin of the orbit, some teeth are canine-like, and the intestine is short in the larval walleye.

Chromatophores are more numerous in all larval stages of the walleye as compared with the yellow perch. They are most distinctive on the yolk sac and on the sides and tips of both upper and lower jaw.

Literature Cited

Bailey, R. M. and W. A. Gosline. 1955. Variation and systematic significance of vertebral counts in the American fishes of the Family Percidae. *Misc. Pub. Mus. Zool. Univ. Mich. (93):1–44, 4 figs.*

Balinsky, B. I. 1948. The development of specific characters in cyprinid fishes. *Proc. Zool. Soc. (118), Pt. II:335–44, 12 figs.*

Evans, H. E. 1948. Clearing and staining small vertebrates in Toto, for demonstrating ossification. *Turtox News (26):42–7, 5 figs.* .

Fish, Marie Poland. 1932. Contributions to the early life histories of sixty-two species of fishes from Lake Erie and its tributary waters. *U. S. Bur. Fish. Bull. 47(10):293–398, 144 figs.*

Hubbs, C. L. 1943. Terminology of early stages of fishes. *Copeia (4):260.*

Leim, A. H. 1924. The life history of the shad (*Alosa sapidissima* (Wilson)) with special reference to the factors limiting its abundance. *Contr. Canadian Biol. N. S. 2 (Pt. I):161–284, 45 figs.*

Mansueti, R. 1956. Alewife herring eggs and larvae reared successfully in lab. *Md. Tidewater News, 13(1):2–3, 1 fig.*

PRITCHARD, A. L. 1930. Spawning habits and fry of the cisco (*Leucichthys artedi*) in Lake Ontario. *Contr. Canadian Biol. and Fish. N. S. 6(9):225–40, 6 figs.*

REIGHARD, J. 1888. The development of the wall-eyed pike. *Ninth Bien. Rept. Mich. State Board Fish Comm. Dec. 1, 1888, to Oct. 1, 1890: 95–158, 10 pls. 64 figs.*

RYDER, J. A. 1886. On the development of osseous fishes, including marine and freshwater forms. *Rept. U. S. Fish. Comm. (1885), (13): 489–604, 30 pls. 174 figs.*

WINN, H. E. AND R. R. MILLER. 1954. Native postlarval fishes of the Lower Colorado River Basin, with a key to their identification. *Calif. Fish and Game 40(3):273–85, 4 pls. 1 fig.*

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A New Genus and Species of Deepwater Ophidioid Fish from the Gulf of Mexico

DANIEL M. COHEN

THIS paper is the first in a series of studies on the ophidioid fishes referred by some authors to the family Brotulidae. Preliminary observations by Dr. C. Richard Robins of the University of Miami and by myself indicate that our present state of knowledge gives us no way of separating the nominal families Ophidiidae (the family name with priority) and Brotulidae. Rather than assign the subjects of my studies to a family at the present time, I prefer to hedge and call them ophidioids, in the hope that further study will provide a firm basis upon which a classification may rest.

The opportunity to examine the remarkable collections of this group of fishes taken by the exploratory fishing investigations of the U. S. Fish and Wildlife Service in the Gulf of Mexico and in the Caribbean provided the original impetus for these studies. I am particularly indebted to Mr. Harvey Bullis for his kindness in sending me specimens, to Dr. Giles Mead of the Museum of Comparative Zoology, Harvard University, for allowing me to examine the holotype of *Acanthonus spinifer*, and to Dr. Vladimir Walters of the American Museum of Natural History for giving me access to the type of *Cherublemma lelepris*. Dr. C. Richard Robins kindly commented on the manuscript.

Although the deepwater ophidioids are probably the predominant fishes at abyssal depths, they are understandably rare in collections, many species being known from only one or a few specimens. My present studies are being carried on in the U. S. National Museum where I have available the important material reported upon by Goode and Bean and by Radcliffe and Smith. At this early stage in my own work, it is apparent that considerable confusion exists concerning the identity of many deepwater ophidioids, and it is hoped that by utilizing the available material, as well as additional specimens that may become available, it will be possible to gain greater insight into the phylogeny of this group.

Xyelacyba *gen. nov.*

Type species *Xyelacyba myersi sp. n.*

Diagnosis.—An ophidioid fish with the symphysis of the cleithra beneath the eyes; ventral fins located under the head immediately posterior to the symphysis of the cleithra; dorsal, caudal and anal fins continuous; pectoral fin with branched rays. Eyes present. Posterior nostril a large pit immediately in front of eye. Body and head covered with scales; a short, indistinct, lateral line present. Opercle and preopercle each with a strong, grooved spine projecting to or beyond the posterior margin of the head; several smaller spines on the preopercle; no spine on the snout. Pseudobranch present but reduced. Gill membranes joined to each other and free from the isthmus for a short distance in front of the symphysis of the cleithra. Some gillrakers elongated. Body compressed; head deep and broad; mouth terminal; dorsal profile of head rounded, snout blunt. Posterior-dorsal portion of maxillary free, not sheathed. Tongue large; vomerine and palatine dentition reduced to narrow bands.

Relationships.—Apparently nearest to *Acanthonus* Günther and *Tauredophidium* Alcock, although quite different from both. It shares with them similar armature on the

opercle and preopercle, and possession of a deep and broad head and strongly compressed body. Some differences from the former are: absence of nasal spines (a double pointed spine present on the snout of *Acanthonus*); presence of a blunt snout and terminal mouth (snout more pointed and mouth inferior and included in *Acanthonus*); supramaxillary and posterio-dorsal portion of maxillary exposed (sheathed in *Acanthonus*); posterior nostril a prominent pit immediately in front of eye (closer to tip of snout than to eye in *Acanthonus*); skin translucent (transparent in *Acanthonus*). In addition, *Xyelacyba* has a shorter snout and a less attenuate body than *Acanthonus*. Other striking differences suggested by superficial observation of the limited material available are to be found in the musculature of the head and the osteology of the ethmoid region. Some differences from *Tauredophidium* are: presence of eyes, position of ventral fin origin close to or ahead of the level of the posterior margin of the maxillary, and distance between the bases of the ventral fins small, one-seventh or less, than the head length. In *Tauredophidium*, on the other hand, functional eyes are degenerate and buried beneath the scale-covered skin, ventral fins originate well behind the level of the posterior margin of the maxillary, and distance between ventral fins is about one-third the head length. In addition, the preopercular armature is less strongly developed in *Xyelacyba* than in *Tauredophidium*.

Comparisons have been made between the types of *Xyelacyba myersi* and the type of *Acanthonus spinifer*, several specimens of *Acanthonus* from the Gulf of Mexico, and illustrations and literature accounts of *A. armatus* (Günther, 1887; Alcock and MacGilchrist, 1905) and *Tauredophidium hextii* (Alcock, 1890, 1902; Alcock and Anderson, 1898). The generic name is taken from the Greek *xyele*—a kind of dagger—and *kybe*—head.

Discussion.—Radcliffe (1913) placed the genera *Sirembo* and *Hoplobrotula* in the subfamily Sirembinae of the Brotulidae. He defined the group as follows: "Clavicular bones greatly produced, meeting below the eye; ventral fins inserted under eyes behind tip of humeral symphysis." Trotter (1926) added the genus *Cherublemma*. *Xyelacyba* would seem to fall into this group as well, were it not for its resemblance, in certain respects, to *Acanthonus* and *Tauredophidium*. In the former there is some variation in the position of the symphysis of the cleithra ("humeral symphysis" of Radcliffe). Günther's (1878) figure of *A. armatus* shows this structure as being at about the same level as the eye. In Alcock and MacGilchrist's (1905) figure of *A. armatus* the symphysis is well behind the level of the eye. Koefoed (1927) states of a specimen identified as *A. armatus*, "Ventrals placed just below end of maxilla." This would mean the symphysis was behind the level of the eye, as is the case in several Gulf of Mexico specimens of *Acanthonus* which I have examined.

Tauredophidium apparently has the symphysis placed well behind the level of the posterior edge of the maxillary. It appears therefore that the single character used to distinguish the Sirembinae is one which is variable in the *Acanthonus-Xyelacyba-Tauredophidium* group, which differs from the Sirembinae in general body proportions, lateral line development, form and number of gillrakers, pseudobranch development, dentition, degree of development of head spines and probably numerous internal characters as well. Indeed the genera *Hoplobrotula* and *Sirembo* appear closer to the Ophidiidae (in the restricted sense) than to any other ophidioid fishes. As for *Cherublemma*, it is a juvenile form, and the type and only known specimen is in such poor condition that it is not possible to either confirm or deny much of Trotter's (1926) original description. The photograph (fig. 33) of the type, however, differs from *Sirembo*, the nearest relative of *Cherublemma* (according to Trotter) in showing a deeper body and head, and Trotter also notes the restricted lateral line. In both of these features, *Cherublemma* comes closer to *Xyelacyba* than to *Sirembo*.

In addition to the type of *Cherublemma lelepris* in the American Museum of Natural History, I have examined two specimens of *Hoplobrotula armata* and two specimens of *Sirembo imberbis* in the U. S. National Museum.

Xyelacyba myersi *sp. n.*

Figure 1

Holotype.—USNM 187058, "Oregon" Station no. 2577, lat. 27°48′ N., long. 88°45′ W., in the Gulf of Mexico, 850–1100 fathoms, July 30, 1959, 40 foot flat trawl. *Paratype.*—USNM 187059. Data as for the holotype. A third specimen, rather badly mutilated, USNM 187060, "Oregon" Station no. 2820,

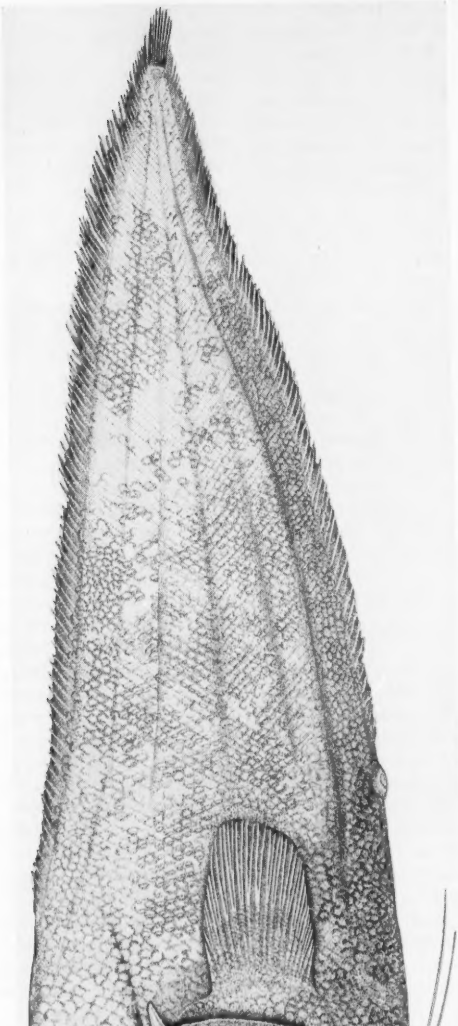

Fig. 1. Holotype of *Xyelacyba myersi*: Drawn by Mildred H. Carrington.

lat. 28°23′ N., long. 88°21.5′ W., in the Gulf of Mexico, 1000 fathoms, July 15, 1960, trawl.

Counts and measurements (in millimeters).—Data for holotype given first, followed by that for paratype in parentheses. D. 87 (?); A. 71 (?); pectoral 19 (19); ventral 2 (2); caudal 9 (9); gillrakers on first arch, upper arm with 4 (5) reduced, angle with 1 (1) long, lower arm with 15 (17) long plus 4 (4) reduced; lateral scale rows about 105 in holotype; branchiostegals 8 in paratype; vertebrae 49; standard length 464 (80); greatest depth 135 (21); depth at vent 126 (17.2); greatest width of head 98.5 (12.7); greatest width at level of vent 64 (4.9); preanal 208 (25.5); preventral 57.5 (8.6); length of pectoral fin 59 (9.5); length of ventral fin 115 (14.0); base of pectoral fin 36.8 (7.0); head length 104 (17.5); snout 28.6 (5.0); horizontal diameter of cornea 13.0 (3.0); tip of snout to posterior margin of maxillary 51 (10.0); greatest depth of maxillary 26.9 (4.5).

Description.—Body foreshortened, compressed; head deeper than long; head width greater than postorbital length of head. Deepest part of fish at level of pectoral fin base, tapering gently to the tail. Dorsal profile of head curving forward rather steeply to the blunt snout. Ventral profile of head rising steeply, interrupted by the pelvic girdle. Skin which covers the abdomen loose and flabby.

Both specimens have lost all of their scales; however, scale pockets are distributed over the entire body and head, although the pockets are not easily distinguishable at the caudal end of the fish. An indistinct lateral line originates at the angle of the opercle and runs posterio-dorsally for a short distance, but it does not reach the level of the vent.

Origin of dorsal fin over pectoral fin. Origin of anal fin close to vent, separated by about 17 mm. in the holotype and two mm. in the paratype. Dorsal, caudal and anal fins continuous; almost all of the dorsal and anal fin rays are broken off short; however, at least some of the dorsal rays near the posterior end of the fin appear to be branched. Pectoral fin inserted vertically, originating on a deep, scale-covered peduncle. Pectoral rays branched, not elongated, the fin extending almost to the level of the origin of the vent in the holotype, slightly beyond in the paratype. Axil of the pectoral fin lacking scales, covered with a thin membranous tissue similar to the lining of the gill cavity, dark brown in the holotype, gray-brown in the paratype. Cleithrum extending forward ventrally to a point beneath the eye. Ventral fins originating behind the symphysis of the cleithra, in the holotype in line with posterior end of the maxillary, in the paratype in line with the posterior margin of the eye; each fin with two simple rays, the medial ray longer, reaching almost to the vent. Bases of the ventral fins separated by a distance of 10 mm. in the holotype, 1.5 mm. in the paratype.

A reduced pseudobranch is present, bearing two or three filaments in the holotype and four filaments in the paratype.

Opercle a narrow bone carrying a long, posterio-dorsally directed spine at the upper angle. The spine has a prominent lateral ridge with a deep groove on either side. The base of the opercular spine is a flat, plate-like structure dorsally and a long, narrow process ventrally, running almost to the base of the longest preopercular spine. In the paratype the entire anterior edge of the base of the opercular spine forms a movable joint with the edge of the preopercle, thus allowing the spine to move in an arc of about 45 degrees. The preopercle, also a narrow bone, carries a series of spines at its lower angle. The anterior margin of the preopercle in the paratype articulates in a movable joint with its anterior neighbor, presumably the hyomandibular. The preopercle swings forward in an arc of about 90 degrees. When both of the opercular elements are extended as far as possible, they lock in place, giving the fish an extremely fierce countenance when viewed head-on. Alcock (1890) notes that the opercle and preopercle of *Tauredophidium* are similarly movable though he does not mention a locking mechanism. On the preopercle the dorsal-most, posterio-ventrally directed spine is the longest, being about equal to the opercular spine, which it also resembles in its arrangement of grooves and ridges. The other two preopercular spines are much less prominent. The long opercular and preopercular spines are proportionally longer in the paratype. A blunt spinous projection is also present below the posterior end of the maxillary. I can not tell for certain from what bone it projects, but it may be the angular. Spines are not present on the snout.

The eyes are sunken and have a smaller diameter than the circle of clear skin through which they are visible. The iris is very narrow; the lens completely fills the pupil.

The posterior nostril is a prominent pit, with its vertical dimension about two times the horizontal. It is separated from its anterior partner by a distance equal to the

height of the posterior nostril. The anterior nostril is a round opening with raised edges. Anterior and ventral to the anterior nostril a fold of skin covers the entrance to a subcutaneous cavity on the snout.

In the holotype, a series of five, darkly-pigmented pores are arranged in a line above the upper jaw. A pair of similar pores are found at the mid-length of each mandible. A series of small papillae, visible only in the holotype, are found in the area of the nostrils.

The dorsal portion of the maxillary is sheathed anteriorly; however, the posterior part of the bone is completely exposed. The posterior margin of the maxillary is very slightly concave. A prominent ridge is present along the ventral margin of the supra-maxillary, where it joins the maxillary. At the anterior tips of both the upper and lower jaws the tooth-bearing areas are separated by narrow, edentulous gaps. The vomerine and palatine dentition is reduced, with the head of the vomer carrying only three diagonal rows of teeth and the wings of the vomer only a single row, as do the palatines. The tongue is an enlarged structure, almost as wide as the mouth. The tongue lacks teeth; however, the basihyals behind it bear three tooth-bearing areas.

The scale pockets of the holotype are uniform, dark brown. The vertical fins and the belly are very dark; the ventral surface of the head is dark brown; the opercular area and the lips are bluish brown. The remainder of the head is white.

Named for Professor George Sprague Myers, my teacher in ichthyology.

Literature Cited

Alcock, A. 1890. Natural history notes from H. M. Indian Marine Survey Steamer "Investigator," Commander R. F. Hoskyn, R. N. commanding.—No. 16. On the bathybial fishes collected in the Bay of Bengal during the season 1889–90. *Ann. Mag. Nat. Hist. Ser. 6, 6:197–222, pls. VIII–IX.*

———. 1902. A naturalist in Indian seas. *John Murray, London. 328 p.*

———, and A. R. S. Anderson. 1898. Illustrations of the zoology of the Royal Indian Marine Survey Ship "Investigator," under the command of Commander T. H. Heming, R. N. Fishes.—*Part V, pls. XVIII–XXIV. Office of the Superintendent of Government Printing, Calcutta.*

———, and A. C. MacGilchrist. 1905. Illustrations of the zoology of the Royal Indian Marine Survey Ship "Investigator," under the command of Captain T. H. Heming, R. N. (Retired). Fishes.—*Part VIII, pls. XXXVI–XXXVIII. Office of the Superintendent of Government Printing, Calcutta.*

Günther, A. 1887. Report on the deep-sea fishes collected by H. M. S. *Challenger* during the years 1873–1876. *Rept. Sci. Res. Challenger, 1873–76, Zool., vol. XXII, lxv + 333. LXXIII pls.*

Koefoed, E. 1927. Fishes from the sea-bottom. *Rept. Sci. Res. "Michael Sars" N. Atlant. Deep-Sea Exped., 1910, vol. 4, pt. 1, 148 p., 6 pls.*

Radcliffe, L. 1913. Descriptions of seven new genera and thirty-one new species of fishes of the families Brotulidae and Carapidae from the Philippine Islands and the Dutch East Indies. *Proc. U. S. Natl. Museum 44:135–76, pls. 7–17.*

Trotter, Elizabeth S. 1926. Brotulid fishes. *Zoologica (N. Y.) 8107–25.*

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A New Species of *Aseraggodes* (Soleidae) from Ceylon

Walter H. Weed, III

Specimens of a new species, *Aseraggodes ocellatus*, were found among a group of shore fishes representing 78 families collected by Dr. James E. Morrow Jr. leader of the Yale-Seychelles Expedition of 1957. The expedition to the Indian Ocean visited Ceylon, as well as the Chagos, Maldive and Seychelles Islands.

In the right-handed soleid genus *Aseraggodes* Kaup, 1858, the pectoral fins are absent, the caudal is free from the anal, the ventrals are sometimes joined to the anal, and the teeth in the jaws are on the blind side only. Uncertainty has beset the definition of *Aseraggodes*. Although Weber and de Beaufort (1929) recognized as valid the genus *Liachirus* Günther, 1862, Chabanaud (1930) considered the two genera synonymous and redescribed the senior synonym *Aseraggodes*, adding considerably to Kaup's inadequate original description. Chabanaud (1930) and my own investigation show that all characters separat-

ing out *Liachirus* are inconsistent. That is, species of both genera, not just of *Liachirus*, apparently have a double lateral line on the blind side. Further, the scales, even on a single individual having a double lateral line, may be either overtly ctenoid or so weakly ctenoid as to appear cycloid. Kaup in his description of *Aseraggodes*, Günther in his description of *Liachirus*, and Weber and de Beaufort in their redescription of the latter genus, after Günther, stated that there are no sensory pores at the bases of the vertical fin rays. Chabanaud (1930) in redescribing *Aseraggodes* did not mention these pores. They are found, however, in the new species *A. ocellatus*.

Aseraggodes ocellatus*, *sp. n.

Fig. 1

DIAGNOSIS

An *Aseraggodes* with two lateral lines on the blind side, the pelvic fin free from the anal, pores at the base of each dorsal and anal ray, the color pattern of the eyed side of ocelli and spots, the eyes close together, the head 23.2–28.0 percent of standard length, the dorsal count 65–70, the anal count 50–54, and the lateral line scale count 94–99.

COUNTS AND MEASUREMENTS

Values for the holotype are followed, in parentheses, by the range of values for the paratypes.

Counts.—Dorsal 66 (65–70); anal 51 (50–54); pelvics 5; pectorals, absent; total caudal rays (unbranched and branched) 18 (2 + 14 + 2); lateral line scales 95 (94–99); gill-rakers, apparently absent; vertebrae 10 + 28 (28–29).

Proportions.—In thousandths of standard length: body depth 462 (395–465), head length 254 (232–280). In thousandths of head length: total length of upper jaw 310 (286–326), eye 172 (160–219).

DESCRIPTION.—(order of characters based on Chabanaud, 1954.)

Head, including nostrils and jaws: On the eyed side the tubular anterior nostril is immediately in front of a vertical through the forward edge of the migrating eye. This tube, when depressed posteriorly, reaches the anterior margin of the fixed eye. The posterior nostril constitutes a slit, which is forward of the fixed eye and confluent with the upper lip.

On the blind side the tubular anterior nostril is just above the mid-point of the upper jaw. The posterior nostril, also tubular, is above and slightly behind the anterior nostril. On the eyed side the maxillary ends under the anterior half of the fixed eye. Papillae fringe the lower jaw. The arched mouth on the eyed side reaches an apex between the anterior and posterior nostrils. Frequently, a shallow fold in the skin extends posteriorly along the right body margin

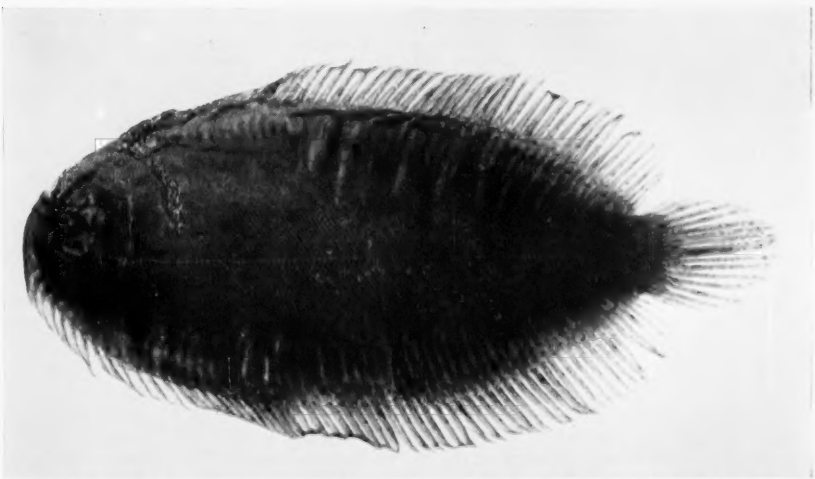

Fig. 1. *Aseraggodes ocellatus*, photograph of the holotype, 57 mm. in standard length, Bingham Oceanographic Laboratory, No. 1288.

from near the mandibular symphysis to the gill slit. At least four rows of minute teeth beset the jaws on the blind side only. Measuring only about 0.1 mm. from apex to base, these teeth are almost entirely embedded in the gums and are difficult to find without aid of a compound microscope.

Fins.—The dorsal originates on the snout at the level of the lower half of the migrating eye. Except for the last five which rapidly decrease in length, the rays of both the dorsal and anal become progressively longer posteriorly. The posterior extremities of the dorsal and anal, when completely spread, are abruptly rounded and free from the caudal, which also is rounded. The two marginal, unbranched rays on each side of the caudal measure less than half the length of the median rays. All the caudal rays except for the two marginals on each side are branched. A vertical from the pelvic insertion passes nearer the posterior margin of the fixed eye than the dorsal lobe of the operculum. Although the pelvic fin on the blind side is somewhat shorter than that on the eyed, both have equal bases. When folded back, the pelvics overreach the anal.

Anus and urogenital orifice.—The anus is located on the blind side against the first anal ray. The well-developed urinary papilla, although almost medial, is directed toward the blind side. In contrast with *A. morrowi* Chabanaud, 1954, no dermal flaps protect the orifice.

Sensory canal system.—On the eyed side a single straight lateral line extends from near the migrating eye to the base of the caudal fin. Both supraorbital and infraorbital branches are present. On the blind side the lateral line extends past the nasal area almost to the snout, from where a second branch runs posteriad, near the dorsal fin, to below the 20th dorsal ray. A sensory pore marks the base of each ray of the vertical fins. Numerous papillae cover the cephalic region, but the region of papillae does not extend back to the opercular slit.

Scales.—The scales on the eyed side are weakly ctenoid; those on the blind side are weakly ctenoid or cycloid. On both sides the small ctenii generally do not show through the skin. Most scales are oval and apparently have 12 radii.

Vertebrae.—The modal vertebrae count, counting the urostyle, is 10 + 29; 6 of 17 counts, however, including that of the holotype, are 10 + 18. The first precaudal vertebra is often difficult to discern. The haemal spine of the first caudal vertebra is more than twice the length of the parapophysis on the last precaudal.

Color.—The brownish eyed side of specimens preserved in 40 percent isopropynol is patterned by numerous, frequently irregular

TABLE 1. COMPARISON OF *Aseraggodes ocellatus* WITH FOUR MORPHOLOGICALLY SIMILAR CONGENERS
(An equal sign (=) denotes a character state for practical purposes identical with that in *A. ocellatus*.)

	A. ocellatus, sp. nov.	*A. macleayanus* Ramsay, 1881	*A. normani* Chabanaud, 1930	*A. morrowi* Chabanaud, 1954	*A. herrei* Seale, 1940
Head length as % of S.L.	23.2–28.0	17.0–20.0	=	=	=
Color pattern	ocelli	vertical bands	punctuated with brownish black	ocelli	specks, lines, blotches of black and small reticulations
Pelvic fin joined to anal	no	yes or no	yes	...	no
Dorsal rays	65–70	=	=	80	77
Anal rays	50–54	=	=	60	=
Condition of anus	papillae no dermal flaps	...	...	simple orifice shielded by dermal flaps	...
Lateral line scales	94–99	=	70–80	=	...

ocellated spots, some of which, in design, approach vermiculations. Smaller solid dark spots, a few of which are near or on the lateral line, are scattered between these ocelli. The blind side, uniformly reddish brown in isopropynol, probably is whitish in life. Small solid dark spots, resembling those on the eyed side of the body, mark some of the rays of the vertical fins. Other lighter spots are aligned in faint, irregular horizontal rows on the vertical fins. Forming vertical rows across the caudal, numerous dark spots are aligned on each caudal ray. Scattered among these on the proximal third of the caudal fin are larger, darker spots.

Specimens Examined

Holotype.—BOC 1288, 57 mm. S.L., collected with rotenone, August 21, 1959 at the north end of Sweat Bay, Trincomalee, Ceylon, depth 0–6 feet.

Paratypes.—BOC 1289, 16 specimens 26–51 mm. S.L., taken with the holotype.

Distribution.—*A. ocellatus* is known only from the types from Ceylon.

Derivation of name.—The specific name, *ocellatus*, refers to the numerous ocellated markings that decorate the eyed side.

Acknowledgments.—I express my thanks to Dr. James E. Morrow, Jr. for collecting the fish and suggesting the problem, also to Dr. Daniel Merriman and Dr. Alfred W. Ebeling for reviewing the manuscript. I am also grateful to Mr. John Howard for the photograph of the holotype. The Yale-Segchelles Expedition on which these specimens were taken was made possible through the generosity of Alfred C. Glassell, Jr.

Literature Cited

Chabanaud, P. 1930. Description d'un nouvel *Aseraggodes* [Pisces, Soleidae] du Queensland. *Ann. Mag. Nat. Hist. (10), 5:241–3.*

———. 1930. Revision de genre *Aseraggodes* Kaup. *Zool. Meded. Mus. Nat. Hist. Leiden, 13(3–4):180–92.*

———. 1954. Description d'un nouvel *Aseraggodes* de la Cote Orientale de l'Afrique. *In* James E. Morrow, Jr. fishes from East Africa, with new records and descriptions of two new species. *Ann. Mag. Nat. Hist. (12), 7:800–02, pl. 24, fig. 1; pl. 25, fig. 2A.*

Günther, A. C. G. L. 1862. Catalogue of the Acanthopterygii, Pharyngognathi, and Anacanthini in the collection of the British Museum. *Cat. Fish. Brit. Mus. 4:1–534.*

Kaup, J. 1858. Abersicht der Soleinae, der vierten Subfamilie der Pleuronectidae. *Archiv Naturg. 24(1):94–104.*

Ramsay, E. P. 1881. Description of two new species of Australian fishes. *Proc. Linn. Soc. N. S. Wales, 5:462–3.*

Seale, A. 1940. Report on fishes from Allan Hancock Expeditions in the California Academy of Sciences. *Allan Hancock Pacific Exped. 9(1):1–46, pls. 1–5.*

Weber, M. and L. F. de Beaufort. 1929. Anacanthini, Allotrognathi, Heterosomata, Berycomorphi, Percomorphi. . . *Fishes Indo-Australian Archipelago, 5:1–458, figs. 1–98.*

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Mugil galapagensis, A New Mullet from the Galápagos Islands, with Notes on Related Species and a Key to the Mugilidae of the Eastern Pacific

Alfred W. Ebeling

The eastern Pacific Mugilidae comprise eight species in four genera, only one of which, *Agonostomus,* occurs primarily in fresh water. However, even though the adults of *A. monticola* inhabit Central American lakes and streams, the prejuveniles (querimanas) are marine and have been dipnetted far at sea off Central America. Two monotypic genera, *Xenomugil* and *Chaenomugil,* are represented by the well-defined species *X. thoburni* and *C. proboscideus*; both are abundant around offshore tropical islands. The species retained in *Mugil* are allocated to the well-defined *M. curema* and *M. cephalus* species groups (Ebeling, 1957). The *curema* group includes *curema, hospes,* and *setosus*; the *cephalus* group *cephalus* and *galapagensis.* Although *M. cephalus* is mainly continental in distribution, *M. galapagensis* apparently is restricted to the Galápagos Islands, a volcanic group about 550 miles west of Ecuador, South America. Besides describ-

ing the new species *M. galapagensis*, this paper purports to clarify the synonymy of eastern Pacific populations of closely related *M. cephalus* by analyzing its considerable intraspecific variability in dentition and to present a much-needed workable key to all species of eastern Pacific Mugilidae.

Most specimens of *M. galapagensis* were collected during the University of California Eastropic Expedition, which briefly visited the Galápagos in 1955. Peruvian and Chilean specimens of *M. cephalus* which are now in the Scripps collections (hereafter abbreviated SIO) were collected especially for this study by the helpful agencies of Sr. Raúl Cortés, Director of the Departmento de Investigaciones Agricolas, Santiago, Chile and Sr. E. Guimoye of Lima, Perú. Mr. Teodor Nalbant, Bucarest, Roumania, donated several specimens of *M. cephalus* from the Black Sea for comparison with eastern Pacific forms. Other material was borrowed from the United States National Museum (USNM) through the courtesy of Dr. Leonard P. Schultz; from the Stanford Natural History Museum (SU), Miss Margaret Storey; and from the University of California at Los Angeles (UCLA), Dr. Boyd W. Walker. Dr. John E. Randall, University of Hawaii and Dr. Donald P. deSylva, University of Miami, Florida made necessary observations of the dentition of *M. cephalus* from these areas. Mrs. Sarah W. Richards and Dr. Daniel Merriman of the Bingham Oceanographic Laboratory, Yale University read and criticized the manuscript. My sincere thanks go to all these people.

Counts and Measurements

For both counts and proportions the range in values of all specimens precedes the value, in parenthesis, for the holotype. All measurements are calculated as proportions in thousandths of the standard length. All counts and measurements except those already described in Hubbs and Lagler (1949) are explained below.

Counts.—scale rows, all oblique rows from scale touching posterior opercular tip to scale overlapping caudal base; *predorsal scales*, shortest series from tip of snout to dorsal origin; *vertebrae*, all centra from and including atlas to and including urostyle (precaudal and caudal counts are given separately; the first caudal vertebra has a well-developed, recurved haemal spine); *right preorbital spines*, all spines even preliminary dull ones; *teeth in upper jaw*, all primary teeth *(i.e.,* those in first row) in right side of upper jaw.

Measurements.—body depth, at first dorsal spine, directly ventrad; *between first and second dorsals*, first dorsal origin to second dorsal origin; *postdorsal*, end of second dorsal to caudal base; *head depth*, occiput (point over posterior tip of preopercle) vertically downward; *interorbital*, the least bony width; *prepectoral*, tip of snout to pectoral insertion; *prepelvic*, tip of snout to pelvic insertion; *pelvic to anal*, pelvic insertion to anal origin; *preanal*, tip of snout to anal origin; *length of pectoral axillary scale*, anterior base of first pectoral ray to tip of scale; *thickness of upper lip*, greatest thickness near symphysis; *orbit to cheek angle*, bony orbit to posterior tip of preopercle (slightly squeezing dividers or calipers); *chin length*, middle of small bony convexities in medial teardrop-shaped area on chin to tip of mandible; *chin width*, greatest width between extremes of gape.

Species Account

Except where direct reference is made to the prejuveniles, this account pertains to half-grown and, perhaps, adults (no sexually mature specimens were found), primarily the holotype and six paratypes.

***Mugil galapagensis**, sp. n.*

Fig. 1

Mugil cephalus (probable misidentifications).—Jordan and Bollman, 1890:180 (Galápagos: Chatham I., Hood I.). Snodgrass and Heller, 1905:352–353 (Chatham I., Hood I.). Seale, 1940:15 (Tower I.). Fowler, 1944:321 (James Bay, James I.).

Mugil ţammelsbergi (misidentification).—Ebeling, 1957:173–4, 176–8, 182–3, figs. 1F, 3C, 6D, 7E, pl. 1A (dentition).

Distribution

As far as known, *M. galapagensis* occurs only among the Galápagos Islands.

Counts and Measurements

Counts and proportions are based on the holotype and 6 paratypes, 129–199 mm. in standard length.

Counts.—dorsal IV, 9; anal III, 8 (II, 9 in juveniles); caudal 7 + 7; pectoral I, 16–17 (I, 16); pelvic I, 5; scale rows 43–45 (44); predorsal scales 25–26 (26); vertebrae 11 + 13; gillrakers 30–39 + 52–64 (39 + 64); spines on right preorbital 15–18 (15); primary teeth on right half of premaxillary 56–81 (81).

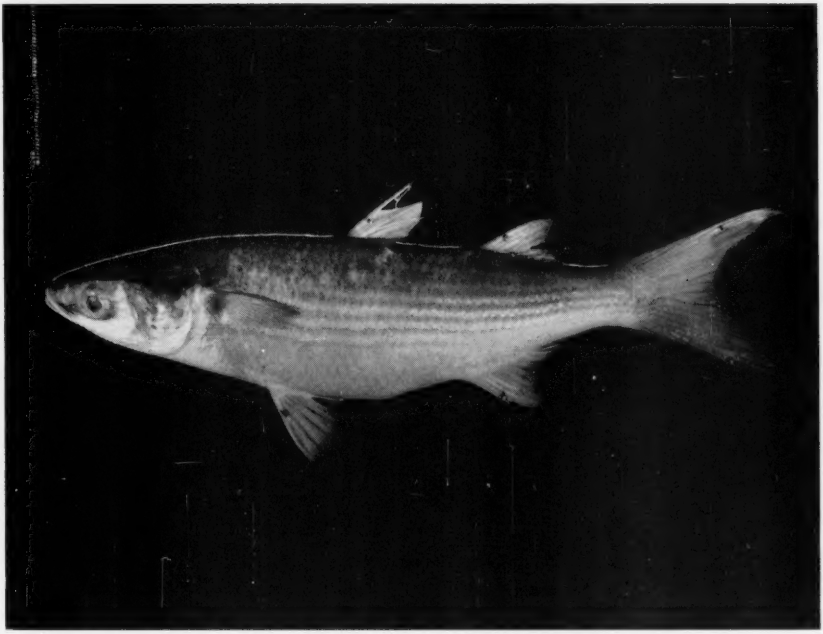

Fig. 1. *Mugil galapagensis*, holotype, 185 mm. standard length, U. S. National Muesum No. 190589.

Proportions.—body depth 249–273 (255); predorsal 494–522 (494); between first and second dorsals 219–240 (230); postdorsal 271–298 (271); head length 270–277 (270); head depth 170–183 (183); head width 163–174 (171); interorbital 110–122 (119); prepectoral 274–291 (285); prepelvic 402–418 (408); pelvic to anal 293–345 (320); preanal 639–727 (725); second dorsal base 100–109 (100); anal base 109–123 (118); second dorsal height 141–149 (145); anal height 130–149 (144); pectoral 163–189 (176); pelvic 147–162 (150); length of caudal peduncle 199–215 (206); depth of caudal peduncle 101–104 (103); length of pectoral axillary scale 61–78 (65); upper jaw 74–79 (75); thickness of upper lip 11–16 (11); snout length 66–77 (72); orbit to cheek angle 93–102 (97); chin length 104–110 (109); chin width 72–84 (75); eye 50–62 (54).

Description

Diagnostic of the species, the distinctive dentition is figured and described in detail in Ebeling (1957, under "*M. rammelsbergii*"). In contrast with *M. cephalus*, only bifid teeth make up the uniserial primary row (external row) of each jaw (fig. 3). In dentition both jaws are alike: secondary band (behind primary row) wide, of 12–13 rows (possibly fewer) in large halfgrown or adults, 1–4 rows in young and prejuveniles (shorter than 50 mm.); separated from primary row by indistinct hiatus; secondary teeth only slightly smaller than primary; gum relatively wide.

Caudal peduncle barely twice as long as deep. Head about 0.27 times standard length, depressed, at preopercular edge as wide as deep. Adipose eyelid present, but not developed in young. Eye 0.67 snout length, which is half fleshy interorbital. Length of posterior slitlike nostril half distance between it and round anterior nostril. Chin width (between extremes of gape) subequal upper-jaw length. Preorbital bone triangular; anteroventral edge straight or slightly concave anteriorly, with 18 serrations in halfgrown, 7–13 in prejuveniles; posterodorsal edge smooth. Surface sculptured: bony shelf arches over medial trough, a second trough extending along posterodorsal margin (fig. 2). Mouth terminal, tip of lower jaw barely overlapping upper. No symphyseal knob. Lower lip narrow, projecting horizontally or folded slightly downward, revealing several rows of teeth. Upper

Fig. 2. Right preorbital bone of *Mugil galapagensis*, ×2.0.

lip width about 0.67 times distance between anterior and posterior nostrils. Maxillary and premaxillary not recurved posteriorly. Palate and tongue toothless; epithelium with fleshy nodules or small spiniform papillae. Epithelium behind gums convoluted. Pharyngeal filter consists of 2 large fleshy pads of hundreds of simple, needle-like teeth on either side of pharynx and numerous close-set gill-rakers, which become more numerous with increasing length of fish. Pseudobranchae well-developed. Most of head sensory canals covered with thin membrane underlying adipose eyelid. Infraorbital canal with 7 branches, ending in pores at edge of adipose eyelid. Supraorbital canal with 6 pores above eye, 3 along preorbital bone.

Scale rows usually 44. Median fin bases lightly scaled: on anal scales cover only proximal halves of first 5 or 6 interradial membranes, on caudal only the proximal two thirds of fin. Scales about 18 on cheek and preopercle, 26 or 27 on rest of operculum and branchiostegal membrane, 50 on top of head, in small series over preorbital bone. Typical body scale smooth, but with microscopic ctenii on posterior field. Pectoral axillary scale 0.4 times pectoral length. Pelvic axillary scale half pelvic length.

First dorsal fin originates midway between tip of snout and caudal base; second dorsal slightly behind anal origin, first ray soft. Distance between dorsal origins less than distance between second dorsal origin and caudal base. Dorsal heights subequal postorbital length. Anal slightly falcate, its base slightly longer than second dorsal base. Pectoral usually I, 16; 4 of 16 counts (on both sides) I, 17; length about 0.75 times head length. Pelvics insert well-behind midpoint between snout and anal origin. Pelvic to pectoral insertion equals distance, pectoral insertion to front of pupil. Pelvic insertion to anal origin equals distance anal origin to caudal base.

Pyloric caeca 2, upper 0.75 length of lower; straight or slightly curved. Muscular gizzard well-developed.

Dorsum in alcohol bluish to brownish grey. Flanks whitish to silvery, with 5 or 6 vague longitudinal stripes. Venter, including pelvics and ventral surface of head, uniformly whitish. Top half of upper lip stippled with a few inconscipuous melanophores; preorbital bone and maxillary darker. Upper head and operculum dark; lower operculum and cheek silvery. Edges of second dorsal and caudal dusky but not marginally banded. Pectoral insertion with conspicuous dark blotch. Peritoneum black. Prejuveniles countershaded, with scattered melanophores on upper flanks, no longitudinal stripes. Lower body not brightly iridescent as in *M. cephalus*. Chin and cheek weakly or not pigmented.

Size at Maturity

None of the type specimens, ranging from 129–199 mm., is sexually mature. Metamorphosis from prejuvenile to young apparently occurs between 25 and 30 mm.

Comparisons

The bifidity of all teeth in the primary rows of each jaw distinguishes *M. galapagensis* from *M. cephalus* (one specimen of *M. cephalus* from the Gulf of California has 3 bifid teeth in the primary upper-jaw row; a single specimen from Venice, Italy has a few scattered in this row). The multiplication of secondary tooth-rows in *M. galapagensis* is shared only by the South American *rammelsbergii*-form of *M. cephalus*. Closely related *M. cephalus* also averages fewer scale rows (usually 40–43).

Sympatric *Xenomugil thoburni* has more anal rays (total elements 12), no bifid teeth in the jaws, generally more scale rows (usually 46), a thicker upper lip, and, in the adults, its lower lip noticeably turned under. Among numerous other differentiating characters, sympatric *Chaenomugil proboscideus* has bifid pharyngeal teeth, has more anal rays (total elements 13–14), and lacks an adipose eyelid in all growth stages. No species in the *Mugil curema* group (*curema, hospes, setosus*) has bifid teeth in the jaws. Also, the anal rays of all three species total 12. *Agonostomus* has palatal teeth, a total anal count of 12, no

adipose eyelid in any growth stage, and overtly ctenoid scales.

Remarks

Two old specimens, USNM 26682, belonging to the *M. cephalus* group are labelled *Mugil rammelsbergii*, Perú, (141) National Museum, and Museum of Comparative Zoology (Harvard). A metal tag repeating the USNM number is free in the jar. The smaller specimen (112.8 mm.) clearly is *M. cephalus*; its primary teeth are simple. The larger (143.7 mm.), however, is *M. galapagensis*; it has only bifid teeth in the jaws and 44 scale rows. Because a paratype of *M. galapagensis* has the next number in series (26683), was also donated from the MCZ, and is clearly labelled "Galápagos Is.," it is reasonable to suspect that 2 collections, one from Perú and one from the Galápagos Islands became mixed, thus accounting for the appearance of the 2 allopatric species in one collection.

A large (198 mm.) specimen of *M. galapagensis* shares a jar with the holotype of *Xenomugil thoburni* (Jordan and Starks, 1896) in the Stanford University collections. Free in this jar are tags SU 354 and 1607. These distinct species may have been mistakenly placed together during the cleanup following a damaging earthquake. Besides having teeth characteristic of *M. galapagensis*, this large specimen has III, 8 anal rays. This definitely refers it to the *M. cephalus*-group. The second specimen (119 mm.), having III, 9 anal rays and having lips, dentition, and scale count typical of *X. thoburni*, is the holotype of *thoburni*.

Derivation of Name

The species name *galapagensis* implies the restriction of the species to the Galápagos Islands.

Specimens Examined

17 from 8 collections.

Holotype.—USNM 190589; sexually immature; 185.0 mm.; Barrington I., Galápagos, at rocky point and small sandy cove of bay on S.E. corner of island; depth of water 5–6′; bottom, sand and rocks; rotenone poisoning; morning 26 Nov. 1955; A. W. Ebeling and party, R/V "Horizon".

Paratypes.—UCLA55-314, data as for holotype, 4 specimens (129.4–154.3 mm., standard length); SIO55-256, data as for holotype, 1(138.2); USNM 26683, Galápagos Is., gift from Museum of Comparative Zoology, Harvard, 1(199).

Additional material.—SU 1607 or 387, Galápagos Is. (In jar with holotype of *Xenomugil thoburni*—see "Remarks"), 1(198); UCLA53-141, Tower Is., Galápagos, dip net under night light, B. Halstead and party, 6(29–46); UCLA54-290, Galápagos Is., dip net under night light, 2(8.9–22.0); USNM 190588 (originally 26682, labeled "Peru", but probably from Galápagos, gift from Museum of Comparative Zoology at Harvard—see "Remarks"), 1(143.7).

Relationship with *M. cephalus*

Although Briggs (1960:178) in listing *M. cephalus* as circumtropical suggested that "... detailed morphological investigation [might] disclose [it to be] a complex of species or subspecies," my investigation indicates that it is in fact a circumtropic-subtropic species. Mindful of the confusion as to the distribution of *M. cephalus* I compared the specimens from California and the west coast of Central and South America with similar specimens from Hawaii, Florida, Venice (Italy), and the Black Sea; all were undoubtedly conspecific. Nevertheless, *M. cephalus* exhibits considerable morphological variability in the eastern Pacific, especially off the west coast of South America. This variability appears more pronounced than that shown between populations of *M. cephalus* in Florida by deSylva, Stearns, and Tabb (1956). In dentition this is immediately obvious: insular *M. galapagensis*, a probable offshoot of near-continental *M. cephalus*, has a modified dental pattern distinct from even the extreme variants of *M. cephalus* that inhabit the islands nearer the mainland.

Because of this heterogeneity, especially in dentition, two other nominal species in the *cephalus*-group from Perú, Chile, and offshore islands have been described. As suggested by Morrow (1957:23) these two, *M. rammelsbergii* Tschudi, 1845 and *M: peruanus* Hildebrand, 1946 (p. 424–6) should be synonymized with *M. cephalus*, since, as indicated below, these two forms are merely extreme variants of the same species. To summarize, the following forms can be distinguished on the basis of dentitional differences: 1) *peruanus*-form, Perú; 2) *cephalus*-form, California to Chile, including Gulf of California; 3) *rammelsbergii*-form, Perú, including near offshore islands; and 4) non-intergrading *M. galapagensis*, Galápagos Is.

Status of *M. rammelsbergii* and *peruanus*

Hildebrand distinguished "*M. peruanus*" from *M. cephalus* by the following: *peruanus* has 1) rougher scales, 2) a browner and more translucent opercle, 3) less silvery young, 4) a darker body, which is punctulated brownish, apparently without lateral stripes, 5) premaxillary teeth in only two well-separated series, with but a few teeth scattered between, and 6) usually uniserial mandibular teeth. Reexamination of Hildebrand's holotype and paratypes of *M. peruanus* showed no measurable difference in scale texture between these specimens and typical specimens of *M. cephalus* and *M. galapagensis*. The translucency of the opercles appears to be an artifact of preservation, not a specific difference. The holotype and paratypes of *M. peruanus* are a bit more brownish than usual, but other specimens are not consistently so. The lack of the prejuvenile sheen, typical of *M. cephalus*, perhaps presages the brownishness of the larger specimens. The brownish young and halfgrown, which have relatively weak lateral stripes, may be ecophenotypes that inhabit the characteristically muddy rivers and estuaries along coastal Perú and Chile.

The taxonomic status of the nominal species *Mugil rammelsbergii* Tschudi has been uncertain. Even though it had long been synonymized with *M. cephalus* (*e.g.*, see Jordan and Swain, 1884; Abbott, 1899; and Evermann and Radcliffe, 1917), Hildebrand (1946:421) resurrected and redescribed *rammelsbergii* to account for several specimens with unusually numerous rows of secondary teeth in the jaws. This was done on the authority of Tschudi's statement, "Die Zahne sind sehr zahlreich, aber fein" (Tschudi's description repeated by Abbott, 1899). Hildebrand further distinguished *M. rammelsbergii* from *M. cephalus* by: 1) its (*rammelsbergii*) thicker lower jaws, the inner surface of which is convex instead of flat, and 2) its wider mouth. However, he qualified the distinctness of both *M. rammelsbergii* and *M. peruanus* by admitting both the impossibility of identifying many smaller specimens in this *cephalus* complex, and the extensive intergradation of characters between these specimens. After examining series of both the *rammelsbergii* and *cephalus* forms, however, I find neither of these differences measurable. The dentitional differences for both *M. peruanus* and *M. rammelsbergii* will be evaluated below.

Dentitional Variation

In his account of the intraspecific variation of dental pattern of Peruvian *M. cephalus*, Morrow (1957) decisively proved with 406 specimens that "not only are typical *cephalus* and *rammelsbergi* forms found but also every conceivable degree of intergradation between the two. . . ." He somewhat arbitrarily divided the dentitional types into 6 categories, the less frequent of which were typical of *rammelsbergii*. He further concluded that "from examination of the completely intergrading dental conditions . . . it is apparent that . . . the condition characteristic of *M. rammelsbergi* represents merely one of the more extreme conditions of individual variation, occurring . . . with a frequency of about 1 in 20." My investigation supports Morrow's findings. Further, reexamination of Hildebrand's material has disclosed the source of his specimens of the extreme *rammelsbergii*-form: Lobos de Tierra Island, off the coast of Perú. It may be that around this and other nearshore islands the *rammelsbergii*-form is the most common. San Lorenzo Island, a small island near the Peruvian coast, is the type locality for *M. rammelsbergii*.

Ebeling (1957:178, footnote to table 1) implied that only in adults and large halfgrown do small bifid teeth form secondary mandibular bands. Also, he stated that jaws of all adult *M. cephalus* support only 3–4 rows of bifid secondary teeth (*Ibid.*, p. 182). Unfortunately, none of these observations was based on South American specimens. To correct these erroneous impressions, there were examined for the present study 120 specimens of *M. cephalus* (20–455 mm., including *cephalus*, *peruanus*, and intermediate forms) from Perú and Chile, 15 specimens from the Gulf of California, and 8 specimens from coastal Roumania along the Black Sea.

Secondary mandibular teeth are present in most specimens from Perú and Chile: of the 120 young to adult, only 9 halfgrown (80–128 mm., including the holotype of *M. peruanus*) lack these teeth. This is in sharp contrast, however, with the mandibular dentition of the Gulf of Californian specimens reported by Ebeling, which were subsequently reexamined and found to bear no secondary mandibular teeth, and of 10 specimens of *M. cephalus* (92–148 mm.) from the Black Sea, only one of which has these teeth. It may be concluded, therefore, that whereas young and small halfgrown specimens of *M. cephalus* from the Gulf of California generally

lack bifid secondary mandibular teeth, specimens limited to nearshore Peruvian islands and *M. galapagensis* always have these teeth. Finally, specimens from coastal Perú and Chile either lack (less common) or have these teeth.

Premaxillary dentition varies considerably within the *M. cephalus* group. Large halfgrown of *M. cephalus* from the Gulf of California have only 3–4 secondary rows of minute bifid teeth well-separated from the single primary row of simple teeth, while *M. galapagensis* has as many as 13 secondary rows of relatively large bifid teeth hardly separated from the primary row of bifid teeth. Between these extremes are intermediate *peruanus, rammelsbergii,* and other forms. The *rammelsbergii*-form supports as many as 13 rows, yet has simple primary teeth (fig. 3, table 1).

Key to the Species of Mugilidae in the Eastern Pacific

Because the primary function of a taxonomic key is to differentiate species, natural groupings are preserved only insofar as they do not interfere with the clear identification of specimens.

1a. All teeth in each jaw in bands, bifid, shaped like minute claw-crowbars (each tip of pair on bifid end curved back, both tips together forming a pocket between them) with long translucent bony bases 2.5–3.5 times as long as overt tooth (Ebeling, 1957: fig. 2). Total elements in anal fin 13–14. Distance between anterior and posterior nostrils equal length of posterior slit-like nostril. Preorbital bone serrate on ventral margin only. Body depth usually 3.0–3.3 in standard length. West coast of middle America and offshore islands, Socorro I. *Chaenomugil proboscideus* (Günther, 1861).

1b. All teeth in each jaw in bands or single rows, simple or bifid, never shaped like minute claw-crowbars with long bases. Total elements in anal fin 10–12. Distance between anterior and posterior nostrils greater than length of posterior nostril. Preorbital bone serrate on ventral and part of anterior margin. Body depth usually 3.3–4.8 in standard length . . 2

2a. Palatal teeth present, strongly developed on vomer, weaker on palatines. Anal spines 2 in postmetamorphic stages (according to Anderson, 1957:418; and Meek and Hildebrand, 1916:335, specimens as large as 119 and 255 mm. had only 2 anal spines). Adipose eyelid absent in adults and halfgrown. Stomach not gizzard-shaped. Scales with ctenii easily visible with naked eye, thus appearing ctenoid. Middle America, Galápagos Is.; adults—freshwater, prejuveniles—marine. *Agnostomus,* probably *monticola* (Bancroft, 1834).

2b. Palatal teeth absent. Anal spines 3 in postmetamorphic stages. Adipose eyelid present in adults and halfgrown. Stomach gizzard-shaped with bell-shaped, thick-walled muscular crop. Scales with ctenii not easily visible with naked eye, this appearing cycloid 3

3a. Scale rows usually 45–47 (rarely 44). Lower lip in larger halfgrown and adults turned under, mandibular teeth directed anteroventrally. All teeth in each jaw simple, but closely packed and strongly curved; in upper jaw secondary teeth (smaller teeth behind primary row in jaw) scattered, not linearly alined. Upper lip wider than greatest width of the medial teardrop-shaped area formed of the inner edges of hyoid and branchiostegals on chin behind mandibular symphysis. Middle America, Perú, Ecuador, Galápagos Is. . . . . *Xenomugil thoburni* (Jordan and Starks, 1896).

3b. Scale rows usually 36–44 (rarely 45). Lower lip in larger halfgrown and adults never obviously turned under, though mandibular teeth may be directed anteriorly. All teeth in each jaw simple, bifid or both, relatively widely spaced or closely packed, weakly or strongly curved; in upper jaw secondary teeth alined linearly or scattered. Upper lip usually narrower than medial teardrop-shaped area of chin 4

4a. Total elements in anal fin 12. All teeth simple. Secondary mandibular teeth always absent (*Mugil curema* group) . . . 5

4b. Total elements in anal fin 11 (rarely 10). Secondary teeth bifid; primary teeth simple or bifid. Secondary mandibular teeth usually present (*Mugil cephalus* group) 7

5a. Pectoral axillary scale 9–11 per cent of standard length. Primary teeth in jaws barely visible with naked eye, relatively widely spaced, not distinctly curved, and lacking yellow apical tips (Ebeling, 1957; fig. 6, pl. 3). Secondary teeth few (2–30

Fig. 3. Inner surfaces of the upper jaws showing typical parts of the mid-sections containing primary and secondary teeth. C, *Mugil cephalus*: C-0, adult, Gulf of California; C-1, halfgrown, Perú; C-2, halfgrown, Perú; C-3, small halfgrown, Perú; C-4, adult, Lobos de Tierra Is., Perú; C-5, small halfgrown, Perú; C-6, young, Perú; C-7, halfgrown, Perú. G, *Mugil galapagensis*: G-0, large halfgrown, Galápagos Is.; G-1, large young, Galápagos Is.

in half of upper jaw), present only in large halfgrown and adults. Body depth usually 21–24 per cent of standard length. Scale rows 38–43. México, Ecuador
Mugil hospes Jordan and Culver, 1895.

5b. Pectoral axillary scale usually 5–8 per cent of standard length (rarely 9 or 10). Primary teeth in jaws easily visible with naked eye, frequently closely packed, distinctly curved, and having yellow apical tips. Secondary teeth numerous (10–80 in half of upper jaw), present in young and adults. Body depth usually 23–28 per cent of standard length. Scale rows 36–40
6

6a. Generally, in upper jaw no teeth (occasionally 1 or 2) scattered between secondary row of small teeth and primary row of larger teeth. Primary teeth usually not so densely packed that several of a group are touching. Mandibular teeth usually more than half as long as primary upper-jaw teeth. Anal height usually 10–15 per cent of standard length. Baja California; west coast of México; Socorro I., Revilla Gigedo group; Ecuador and northern Perú.....*Mugil curema* Cuvier and Valenciennes, 1836.

6b. In upper jaw teeth of intermediate size scattered between a secondary row of small teeth and the primary row of larger teeth (Ebeling, 1957, fig. 1). Primary teeth usually so densely packed that several of a group are touching. Mandibular teeth usually half or less than half as long as primary upper jaw teeth. Anal height usually 15–18 percent of standard length. Clarion I., Revilla Gigedo group.....*Mugil setosus* Gilbert, 1891.

7a. All teeth in primary row of each jaw simple or at most 1–3 bifid at ends of jaws only in very large adults. Scale rows 39–44 (more rarely 44). Southern California and Gulf of California to South America, including northern Chile; nearshore islands.
Mugil cephalus Linnaeus, 1758.

7b. All teeth in primary row of each jaw bifid. Scale rows 43–45. Galápagos Is.
Mugil galapagensis, n. sp.

Synomymies

To clarify the nomenclature of the eastern Pacific representatives of four species, the following, probably incomplete, synonymies are presented. No types of nominal species were examined; therefore those that were not described diagnostically are necessarily omitted.

Table 1. Geographical Variation in Pattern of Upper Jaw Dentition Within the *Mugil cephalus* Species Group

The states of dentitional pattern, column 2, are coded according to the legend in Fig. 3. States C-0 to C-7 are *M. cephalus* types, G-0 and G-1 are *M. galapagensis* types. Numbers of specimens having the specified states are given under locality by growth stage.

Growth stage	States	Localities				
		Roumania: Black Sea	Gulf of Calif.	Coastal Peru, Chile	Islands off Peru	Galápagaos Is.
Halfgrown to adult	C-0	1	10	3	—	—
	C-1	1	4	15	—	—
	C-2	—	—	1	—	—
	C-3	—	—	43	1	—
	C-4	—	—	—	3	—
	G-0	—	—	—	—	7
Young to halfgrown	C-5	4	1	4	—	—
	C-6	2	—	10	—	—
	C-7	—	—	38	1	—
	G-1	—	—	—	—	6

Other nominal species, listed below, were synonymized on the basis of diagnostic combinations of characters winnowed from their original descriptions.

Agonostomus monticola (Bancroft, 1834). Whether or not *Agonostomus* comprises more than one species in the eastern Pacific is uncertain (see Meek and Hildebrand, 1916:335–6). *A. hancocki* Seale, 1940 was described from the Galápagos Is., but in Seale's description no usable differentiating characters were given.

Chaenomugil proboscideus (Gunther, 1861). Probable synonym: *Myxus robustus* Mohr, 1927.

Mugil curema Cuvier and Valenciennes, 1836. Probable synonyms: *Neomyxus ciliilabus* (Cuvier and Valenciennes, 1836) (see Hildebrand, 1946:426); *Mugil charlottae* Steindachner, 1902 (Anal III, 9; scale rows 40).

Mugil cephalus Linneaus, 1758. Synonyms: *Mugil rammelsbergii* Tschudi, 1845, *Mugil peruanus* Hildebrand, 1946. Probable synonyms: *Myxus niger* Mohr, 1927 (Lima, Perú; anal III, 8; scale rows 43); *Myxus lepidopterus* Mohr, 1927 (Perú; anal III, 8; scale rows 40). For further synonymy see Fowler

primary and secondary teeth. C, *Mugil cephalus*, Perú; C-4, adult, Lobos de Tierra Is., Perú; Perú; C-2, halfgrown, Perú; C-3, small halfgrown, Perú; C-6, young, Perú; C-7, halfgrown, Perú. G, *Mugil galapagensis*: G-0, C-5, small halfgrown, Perú; C-6, young, Perú; C-7, halfgrown, Perú. G, *Mugil galapagensis*: G-0, large halfgrown, Galápagos Is.; G-1, large young, Galápagos Is.

(1944:321). The specimens listed as *Mugil curema* by Hildebrand (1946:426–8) are prejuveniles of *M. cephalus.*

Summary and Conclusions

Mugil galapagensis, n. sp., here described from the Galápagos Islands, is closely related to *Mugil cephalus,* a pantropic-subtropic nearshore species found in North, Central, and South America. The dental pattern of *M. cephalus* varies considerably, especially along the coast of Perú and among offshore islands (Table 1). This probably has led to the naming of two extreme variants of *M. cephalus,* the nominal species *Mugil peruanus* and *M. rammelsbergii.* These are shown to be synonyms of *M. cephalus.* Although many specimens of mainland *cephalus* have what might be interpreted as *rammelsbergii*-type dentition, four specimens from a Peruvian nearshore island have an even more extreme type. Unfortunately, the dentition of the mainland specimens cannot be compared statistically with that of the island specimens, since so few of the latter were available. Because, however, species characteristic of the island habitat (*e.g., Chaenomugil proboscideus*) have dentitions analogous to the *rammelsbergii*-type (*i.e.,* including many rows of bifid secondary teeth), it is suggested that the *rammelsbergii*-type is selected as adaptively favorable about the islands and that the mainland *rammelsbergii*-forms may be preadapted to the island habitat. Further, the dentition of *M. galapagensis,* which is restricted to the rocky Galápagos Islands far offshore, is even more extreme: not only are many rows of bifid secondary teeth developed, but the teeth of the primary row are also bifid. Stronger, more numerous bifid teeth could increase the efficiency of browsing on rocks and coral, which predominate in the islands. Conversely, a relatively small number of simple, weak bifid teeth would be adequate for an iliophagous feeding habit (*i.e.,* gulping mouthfuls of sand or mud, passing these through the digestive tract, and digesting off nutritive matter).

The Peru Current, which flows northward along the west coast of South America to bend westward at about 6°S. Lat. (Pta. Agulja, Perú), bathes the Galápagos Islands (0°, 90°W). Here it becomes the South Equatorial Current (Sverdrup *et al,* 1942:702). Perhaps a few individuals of the *rammelsbergii*-form of *Mugil cephalus* were fortuitously borne by this current to the Galápagos. Well-isolated from genetic swamping by mainland populations, their successive generations perhaps further diverged from the mainland forms to evolve *Mugil galapagensis.*

Finally, to survey the eight valid species of Mugilidae in the eastern Pacific, a key presents most of their diagnostic characters. Some of the dubious nominal species from the literature are placed in synonymy with various of the valid species.

Literature Cited

Abbott, James Francis. 1899. The marine fishes of Peru. *Proc. Acad. Nat. Sci. Philadelphia 1899:324–69.*

Bancroft, E. N. 1834. [Description of *Mugil monticola.*] *In* Volume 10, Pisces, The Animal Kingdom . . . by the Baron Cuvier . . . with additional descriptions of species . . . by E. Griffith and others. *London. P. 367, pl. 36.*

Briggs, John C. 1960. Fishes of worldwide (circumtropical) distribution. *Copeia 1960 (3):171–80.*

Cuvier, G. L. C. F. D., and A. Valenciennes. 1836. Volumn 11. Histoire naturelle des poissons. *Paris, Chez f. G. Leurault. 505 p.*

de Sylva, Donald P., Howard B. Stearns, and Durbin C. Tabb. 1956. Populations of the black mullet (*Mugil cephalus* L.) in Florida. *Florida State Bd. Conserv. Tech. Ser. (19):7–45, figs. 1–10.*

Ebeling, Alfred W. 1957. The dentition of eastern Pacific mullets, with special reference to adaptation and taxonomy. *Copeia 1957(3): 173–85, figs. 1–7, pls. 1–3.*

Evermann, Barton Warren and Lewis Radcliffe. 1917. The fishes of the west coast of Peru and the Titicaca Basin. *Bull. U.S. Natl. Mus. (95):1–166, pls. 1–14.*

Fowler, Henry W. 1944. The fishes. *In* Results of the Fifth George Vanderbilt Expedition (1941) (Bahamas, Caribbean Sea . . . .). *Monogr. Acad. Nat. Sci. Philadelphia (6):57–529, figs. 1–268, pls. 1–20.*

Gilbert, Charles H. 1891. Descriptions of 34 new species of fishes collected in 1888 and 1889, principally among the Santa Barbara Islands and in the Gulf of Mexico. *Proc. U.S. Natl. Mus. 14:539–66.*

Günther, Albert. 1861. Volume 3. Catalogue of the acanthopterygian fishes in the collection of the British Museum. *London, British Museum (Nat. Hist.). 586 p.*

Hildbrand, Samuel F. 1946. A descriptive catalog of the shore fishes of Peru. *Bull. U.S. Natl. Mus. (189):1–530, figs. 1–95.*

Hubbs, C. L. and K. F. Lagler. 1949. Fishes of the Great Lakes Region. *Bull. Cranbrook Inst. Sci. 26:1–186.*

Jordan, David Starr (Assisted by Edwin Chapin Starks, George Bliss Culver, and Thomas Marion Williams). 1895. The fishes of Sinaloa. *Contrib. Biol. Hopkins Lab. Biol. 1:377–514, pls. 27–55.*

Jordan, David Starr and Charles Harvey Bollman. 1890. Scientific results of explorations by the U.S. Fish Commission Steamer Albatross. No. 4. Descriptions of new species of fishes collected at the Galapagos

Islands and along the coast of the United States of Colombia, 1887–'88. *Proc. U.S. Natl. Mus. 12:149–83.*

JORDAN, DAVID STARR AND E. C. STARKS. 1896. [Description of *Mugil thoburni.*] *In* Jordan, David Starr and Barton Warren Evermann, The fishes of North and Middle America . . . , Part 1. *Bull. U.S. Natl. Mus. (47):1–1240.*

JORDAN, DAVID STARR AND J. SWAIN. 1884. A review of the American species of marine Mugilidae. *Proc. U.S. Natl. Mus. 7:261–75.*

MOHR, ERNA. 1927. Mugiliden—Studien. *Zool. Jahrbucher (Abt. Syst., Okol. Geog. Tiere), 54:179–202, figs.*

MORROW, JAMES E. 1957. Shore and pelagic fishes from Peru, with new records and the description of a new species of *Sphoeroides. Bull. Bingham Oceanogr. Coll. 16 (Art. 2):5–55, figs. 1–12.*

SEALE, ALVIN. 1940. Report on fishes from Allan Hancock Expeditions in the California Academy of Sciences. *In* Allan Hancock Expeditions, Vol. 9, No. 1. *Los Angeles, Univ. of California Press. 40 p. 5 pls.*

SNODGRASS, ROBERT EVANS AND EDMUND HELLER. 1905. Papers from the Hopkins-Stanford Galapagos Expedition, 1898–1899. No. 17. Shore fishes of the Revillagigedo, Clipperton, Cocos and Galapagos Islands. *Proc. Washington Acad. Sci. 6:333–427.*

STEINDACHNER, FRANZ. 1902. Herpetologische und ichtyologische ergebnisse einer reise nach Südamerika. *Denkschr. Kaiser. Akad. Wissensch. Wien 72:89–148, pls. 1–5.*

SVERDRUP, H. U., MARTIN W. JOHNSON, AND RICHARD H. FLEMING. 1942. The oceans. . . . *New York, Prentice-Hall, Inc. 1087 p. 265 figs. 7 charts.*

VON TSCHUDI, JOHAN JACOB. 1845. Untersuchungen über die Fauna Peruana. Ichthyologie. *Gallen, Sheitlin, and Zoolikofer (1844/46). 35 p.*

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Two New Cottid Fishes from the Fresh Waters of Eastern United States[1]

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RECENT studies of the American freshwater sculpins revealed the presence of several undescribed yet very distinctive species and subspecies of *Cottus* in the eastern United States. Preliminary diagnosis of some of these forms appears desirable to permit their inclusion in faunal studies of others. Two are described here.

Edward C. Raney generously made available material in the Cornell University collection and has constantly encouraged and aided the writer. Reeve M. Bailey and Robert R. Miller provided facilities for study at the University of Michigan Museum of Zoology and have freely loaned specimens in their care. Their discussions of the prolems involved have been especially valuable. At the United States National Museum, Leonard P. Schultz, Ernest A. Lachner, Robert H. Kanazawa and Isaac Ginsburg similarly have provided space and specimens and have been a ready source of advice. Earl E. Deubler, Jr. assisted in tabulating the data. The completion of this paper was made possible by a Grant-in-aid (NSF-G-7116) from The National Science Foundation.

METHODS AND ABBREVIATIONS

Except as noted by Robins and Miller (1957:214–8), the counts and measurements are as defined by Hubbs and Lagler (1947:8–15). All measurements were made to the nearest tenth of a millimeter with the aid of dial calipers. The lateral-line length is taken from the snout tip to the most posterior pore. Thus in some species this may exceed the standard length.

Abbreviations used to denote morphological features are: spines in the spinous dorsal fin, I-D; rays in the second dorsal fin, II-D; anal rays, A; pectoral rays, P; pelvic (ventral) rays, V; lateral-line pores, L.L.P.; preopercularmandibular pores, P.O.M.; length of lateral line, L.L.; standard length, S.L.; head length, H.L., length of caudal fin, C.F.; length of pectoral fin, P.L.; length of pelvic fin, V.L.; longitudinal diameter of eye, E.L.; least depth of caudal peduncle, C.P.

In citing the locality data the following abbreviations are used in addition to those standard for compass directions: Br.—branch,

[1] Based on portions of a thesis presented to the faculty of the Graduate School of Cornell University in partial fulfillment of the requirements for the degree of Doctor of Philosophy. Contribution No. 319 from The Marine Laboratory, University of Miami.

TABLE 1. NUMBERS OF FIN RAYS AND LATERAL-LINE PORES OF SPECIMENS OF *Cottus girardi* AND *Cottus b. bairdi* FROM THE POTOMAC RIVER SYSTEM

(N = sample size, $\bar{x}$ = mean, s = standard deviation and $2S_{\bar{x}}$ = twice the standard error of mean)

	First Dorsal Spines								Second Dorsal Rays							
	6	7	8	9	N	$\bar{x}$	S	$2S_{\bar{x}}$	15	16	17	18	N	$\bar{x}$	S	$2S_{\bar{x}}$
C. girardi	2	46	24	2	74	7.35	.58	.14	—	22	48	4	74	16.76	.54	.13
C. b. bairdi	3	69	33	2	107	7.23	.52	.10	2	41	58	6	107	16.64	.62	.12

	Total Dorsal Elements										Pelvic Rays			
	21	22	23	24	25	26	27	N	$\bar{x}$	S	$2S_{\bar{x}}$	3	4	N	$\bar{x}$
C. girardi	—	—	20	32	18	2	2	74	24.11	.93	.22	—	150	150	4.00
C. b. bairdi	1	1	29	49	23	3	—	106	24.00	.85	.17	10	200	210	3.95

	Anal Rays									Pectoral Rays							
	10	11	12	13	14	N	$\bar{x}$	S	$2S_{\bar{x}}$	13	14	15	16	N	$\bar{x}$	S	$2S_{\bar{x}}$
C. girardi	1	4	36	30	3	74	12.40	.72	.17	—	8	131	15	154	15.00	.38	.06
C. b. bairdi	—	—	29	65	12	106	13.16	.60	.12	5	149	10	—	214	14.26	.49	.07

	Lateral-line pores													
	17	18	19	20	21	22	23	24	25	26	N	$\bar{x}$	S	$2S_{\bar{x}}$
C. girardi	2	2	1	7	6	6	6	3	3	—	36	21.44	2.05	.68
C. b. bairdi	—	—	1	3	12	36	30	18	7	1	108	22.65	1.26	.24

[1] N numbers of fins.

Co.—county, Cr.—creek, fk.—fork, hwy.—highway, mi.—mile(s), R.—river, rt.—route, Spr.—spring(s), trib.—tributary of. Collections are listed by their institutional number (CU = Cornell University, UMMZ = University of Michigan Museum of Zoology, USNM = United States National Museum) with the number of specimens and their extremes of standard length in parentheses.

Cottus girardi, *sp. n.*

Potomac sculpin (Tables 1, 3, Figs. 1*a*, *d*)

Material.—The holotype, CU 25607, an adult male, 68.9 mm in standard length was collected in Conochocheague Creek, 9.6 mi. NE of Chambersburg on rt. 11, Franklin Co., Pennsylvania, June 4, 1951 by Edward C. Raney and C. Richard Robins. Four paratypes were taken with the holotype: UMMZ 167174 (4, 38–65). Additional paratypes are: CU 1680 (13, 26–38) Marsh Run at Fiddlesburg, Washington Co., Md., Aug. 9, 1949, R. Mansueti and H. Howden. CU 7363 (10, 29–51) Fifteen Mile Cr., near rt. 40, Allegany Co., Md., Aug. 29, 1938, R. H. McCauley. CU 25605 (1, 63) Shenandoah System ½ mi. E of Stuart's Draft, Augusta Co., Va., July 21, 1952, John and Betty New.

Additional material examined but not designated as paratypes: Pa., Adams Co.: CU 16562 (2, 27–48) Marsh Cr. near Seven Stars on rt. 30, Sept. 2, 1948. CU 18851 (4, 25–40) Trib. Monocacy R. 10 mi. NW of Gettysburg on rt. 30, Aug. 26, 1950. CU 25649 (1, 26) Conochocheague Cr. in Caledonia State Pk., Franklin Co., Aug. 26, 1950.

Va., Loudoun Co.: CU 11393 (7, 26–50) trib. Little R. 1½ mi. W of Aldie, Ap. 13, 1948. CU 25029 (1, 23) Little R., 1 mi. S of Oatlands on rt. 15, June 18, 1946. CU 26065 (17, 35–55) Little R. 1.5 mi. NE of Aldie on rt. 15, March 28, 1954. Rockingham Co.: CU 25651 (1, 79) Rawley Springs, Aug. 12, 1951. CU 25026 (4, 25–69) Mill Race at Glick's Mill, Montezuma, Aug. 12, 1951. CU 1106 (1, 74) Bridgewater, North R., Ap. 10, 1937. CU 16973 (21, 33–64) Muddy Cr., 4 mi. ESE of Rawley Spr. on rt. 33, Ap. 4,

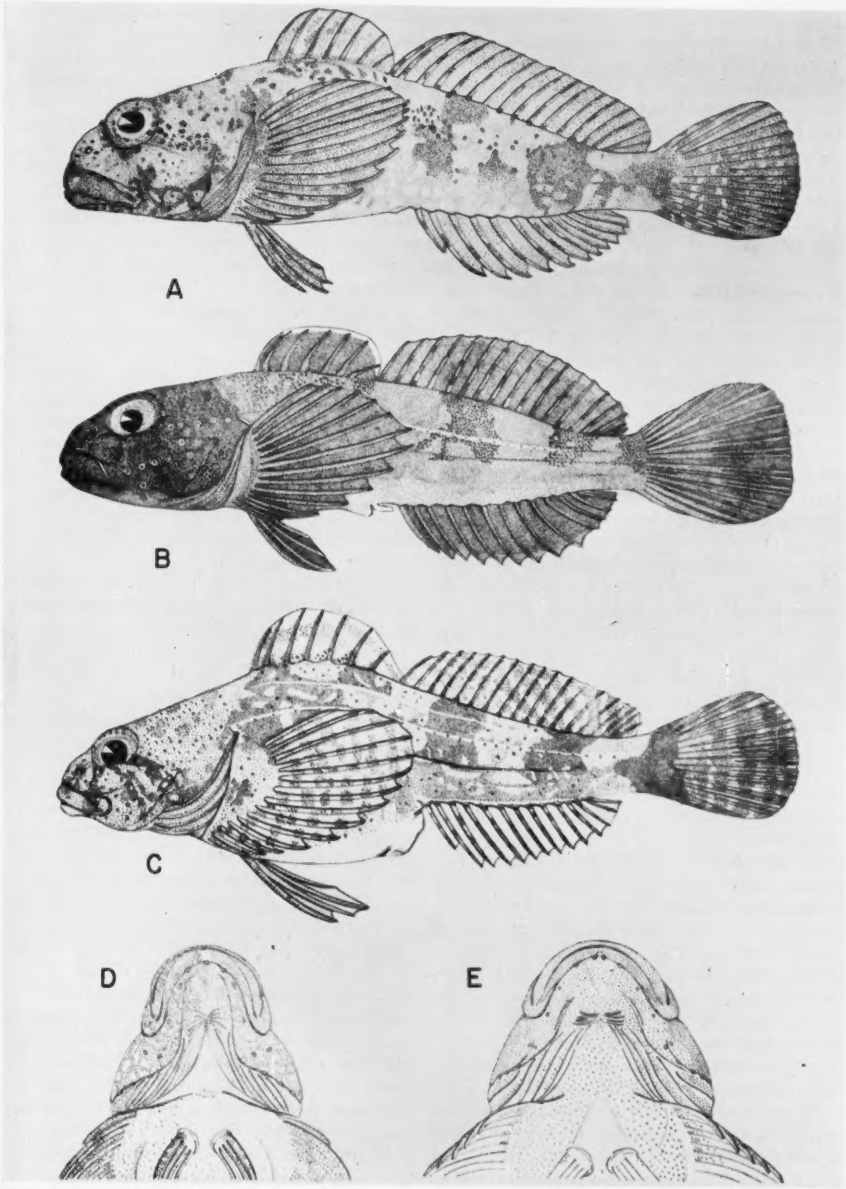

Fig. 1. A. Male holotype of *Cottus girardi*, 68.9 mm standard length (CU 25607, Potomac River system, Franklin Co., Penna.). B. Male holotype of *Cottus baileyi*, 54.5 mm standard length (CU 25914, Holston River System, Smyth Co., Va.). C. Female allotype of *Cottus baileyi*, 54.4 mm standard length (CU 25915, Holston River System, Smyth Co., Va.). D. Underside of head of holotype of *C. girardi* (see A above). Note blotched pigment pattern. E. Underside of head of female of *Cottus b. bairdi*, 63.5 mm standard length (CU 21805, Potomac River System, Augusta Co., Va.). Note uniform pigmentation. All drawings by Thomas W. McKenney.

1947. CU 21658 (1, 83) Christian Cr., 5.2 mi. SE of Staunton, Augusta Co., June 11, 1951.

W. Va., Pendleton Co.: CU 4888 (1, 27) Trib. S. Br. Potomac R., 1 mi. above Franklin, Ap. 14, 1931. CU 13602 (4, 61–96) Seneca Cr., Trib. N. Fk. R., March 17, 1948. CU 25606 (2, 46–65) 3.8 mi. from rt. 50 at ft. of Schaffnaker Mt., Hampshire Co., June 25, 1951. CU 11126 (2, 33–47) S. Br. Potomac R., 5 mi. S. of Moorefield, Hardy Co., May 10, 1941.

Diagnosis.—A moderate-sized species, rarely if ever exceeding 100 mm (S.L.). Head large, usually more than 33 per cent of standard length. Chin strongly mottled. P.O.M. canals joined to form a single anterior median chin pore. Preopercle armed with three spines; the upper and largest projecting posteriorly and dorsad, the lower two, small but well developed, projecting downward and forward. Seventeen to 25 lateral-line pores; lateral line rarely reaching the beginning of the lateral-line deflection. Fourteen to 16 pectoral rays. Counts and measurements (expressed as thousandths of standard length) of the holotype: I-D.—7, II-D—16, A—12, P—15–15, V—4–4, L.L.P.—23, L.L.—565, H.L.—374, E.L.—83, C.P.—87, C.F.—260, P.L.—298, V.L.—199.

Description.—All fins are mottled or spotted with dark brown or black. The spotting is restricted to the surfaces of the spines and rays; only scattered melanophores occur in the interradial membranes. The first dorsal fin, at least in males, has a narrow orange-red border. One male (CU 1106) has a subterminal black band under the red border; the lower half of the fin of this individual is only lightly pigmented. The ground color is pale brown dorsally becoming mottled with light on the lower sides and gradually blending into the pale, unpigmented belly. The ventral unpigmented area often extends caudad along the anal fin to the base of the tail. The isthmus and branchiostegal membranes are variously speckled with black or brown but are never unpigmented. The chin, lips, and cheek are strongly mottled, never uniformly pigmented. A dark bar slopes backward across the cheek from below the eye and a second bar often extends from the rear of the eye to the preopercle. Scattered black spots occur on the head and upper portion of the body. Most consistent is the nature of the banding. There is no band on the body under the first dorsal fin although spots and blotches sometimes suggest the outline of such a pattern. Two narrow, dark bands cross the back under the second dorsal fin. The anterior band passes through the bases of rays 4–6 or 5–7 but involves two or three of these rays at most. The posterior band crosses the dorsum in the region of rays 12–16 but involves only three or four of these rays. Each band is decidedly narrower on the back than the interval between them and this interval often exceeds their combined width. Both bands slope ventrally and anteriorly to the region of the lateral line and then turn ventrally to fade on the lower side. An irregular dark blotch is situated between the two bands on the lower side. A dark vertical bar encircles the base of the caudal rays and extends forward on each side of the caudal peduncle as a dark triangular area. The bands and blotches are never sharply outlined; on the contrary, their irregularity of outline is a diagnostic feature of the species. The breeding male referred to above has the entire body darkened so that the color pattern is largely obscured. It remains to be determined if this characterizes breeding individuals or is an artifact of preservation.

The robust body is deepest at or immediately in front of the first dorsal fin and is widest across the hind portion of the head. The caudal peduncle is narrow (.07–.09 S.L.). The mouth is large, but its shape, the width of the gape, and the distance that it extends under the eye are so largely dependent on preservation that a detailed description seems unwarranted.

Ranges in other proportional measurements expressed as hundredths of standard length are: P.L., 27–31; V.L., 16–24; C.F., 25–29; L.L., 72–86; E.L., 7–10; and H.L., 32–38. Frequency distributions of these proportions are given in Table 3.

No variation in branchiostegal rays was noted; there are six rays on each side, four attached to the ceratohyal and two to the epihyal. Frequency distributions for the various fin-ray counts are given in Table 1. One hidden spine is present in each pelvic fin. There are 12 caudal rays, nine of which are branched and supported by the main elements of the hypural plate. The dorsal fins are contiguous, rarely joined and then only slightly. The pectoral fin is long and pointed, reaching nearly to or beyond the origin of the anal fin.

The degree of prickling of the body is variable. Most are naked or with a few prickles along the anterior portions of the lateral-line canal. Some have a few and others a large patch of prickles mesial to the pectoral fin.

TABLE 2. NUMBERS OF FIN RAYS AND LATERAL-LINE PORES OF SPECIMENS OF *Cottus baileyi* AND *Cottus c. carolinae* (HOLSTON RIVER MATERIAL ONLY)

(N = sample size, $\bar{x}$ = mean, s = standard deviation and $2S_{\bar{x}}$ = twice the standard error of mean)

	First Dorsal Spines							Second Dorsal Rays							
	6	7	8	N	$\bar{x}$	S	$2S_{\bar{x}}$	15	16	17	18	N	$\bar{x}$	S	$2S_{\bar{x}}$
C. baileyi	1	52	36	88	7.40	.52	.11	6	46	45	3	100	16.45	.66	.13
C. c. carolinae	5	97	14	116	7.08	.40	.07	8	47	32	2	89	16.31	.67	.14

	Total Dorsal Elements									Pelvic Rays			
	21	22	23	24	25	26	N	$\bar{x}$	S	$2S_{\bar{x}}$	3	4	N[1]	$\bar{x}$
C. baileyi	2	4	42	43	8	1	100	23.53	.80	.16	—	200	200	4.00
C. c. carolinae	—	7	32	29	19	1	88	23.72	.93	.20	1	177	178	3.99

	Anal Rays								Pectoral Rays							
	11	12	13	14	N	$\bar{x}$	S	$2S_{\bar{x}}$	14	15	16	17	18	N[1]	$\bar{x}$	S	$2S_{\bar{x}}$
C. baileyi	2	29	65	4	100	12.71	.57	.11	25	168	39	—	—	232	15.06	.49	.06
C. c. carolinae	5	40	38	6	89	12.50	.71	.15	—	10	86	79	3	178	16.52	.63	.09

	Lateral-line Pores																
	22	23	24	25	26	27	28	29	30	31	32	33	34	N	$\bar{x}$	S	$2S_{\bar{x}}$
C. baileyi	2	1	17	18	17	2	3	5	5	4	5	1	—	80	26.46	2.70	.60
C. c. carolinae	—	—	—	—	—	—	1	—	2	14	26	23	12	78	32.32	1.15	.26

[1] N-number of fins.

The premaxillary and dentary teeth are well developed and most are depressible. Each of these bands is clearly separated into two lateral patches by a median band of tissue. The vomerine and palatine teeth are likewise well developed and depressible. The length of the large palatine patch exceeds the greatest width of the vomerine patch. This enlargement causes the palatine and vomerine teeth to adjoin closely.

The anal papilla is sexually dimorphic. It is enlarged in males and extends caudad as a rectangular or bluntly V-shaped process which usually exceeds half the distance to the first anal ray and occasionally reaches that point. In females it is a simple, rounded protuberance scarcely larger than the anal opening.

The anus is situated directly under rays 2 or 3 of the second dorsal fin. The origin of the anal fin is under rays 3 or 4.

In describing the lateral-line system of the head, I follow the terminology of Hubbs and Cannon (1935) and the outline of Bailey and Dimick (1949). The more precise preopercularmandibular, as emended by recent authors, however, is adopted. The lateral canal consists of five pores: the first three are above the opercle, pore 4 is above the preopercle, and pore 5 is at the anterior end of the canal immediately behind the eye. Pores 2, 3, and 5 open from ventral branches; pores 1 and 4 are on the canal proper. The supratemporal canal consists of three pores and joins the two lateral canals directly opposite the branch leading to pore 3. The supraorbital canal branches from the lateral canal opposite pore 5. It consists of a coronal pore, on a common canal between the two supraorbital canals, an interorbital pore, a posterior nasal pore and an anterior nasal pore. These pores are arranged precisely as described by Bailey and Dimick (1949:9–10) for *Cottus hubbsi*. A schematic drawing of the pore arrangement was presented by Robins and Miller (1957: figs. 2–3) without intent to depict any one species.

The infraorbital canal branches from the lateral canal in the long space between pores 4 and 5 and consists of nine or ten pores. The first pore is situated immediately behind

TABLE 3. PROPORTIONAL MEASUREMENTS EXPRESSED IN HUNDREDTHS OF STANDARD LENGTH FOR *Cottus girardi* AND *Cottus baileyi*

(N-sample size, x-mean)

	Head Length											Eye Length					
	30	31	32	33	34	35	36	37	38	N	$\bar{x}$	7	8	9	10	N	$\bar{x}$
C. girardi	—	—	1	1	11	8	7	1	1	30	34.87	3	6	3	3	15	8.40
C. baileyi	1	4	7	1	—	—	—	—	—	13	31.62	—	5	7	1	13	8.69

	Caudal-fin Length									Pectoral-fin Length								
	23	24	25	26	27	28	29	N	$\bar{x}$	27	28	29	30	31	32	33	N	$\bar{x}$
C. girardi	—	—	2	3	2	6	2	15	27.20	1	2	5	4	3	—	—	15	29.40
C. baileyi	1	4	5	2	1	—	—	13	24.85	1	1	2	5	2	1	1	13	30.00

	Least Depth of Caudal Peduncle						Length of Lateral Line[1]							
	7	8	9	10	N	$\bar{x}$	70–74	75–79	80–84	85–89	90–94	95–99	N	$\bar{x}$
C. girardi	1	9	5	—	15	8.27	3	2	8	2	—	—	15	80.20
C. baileyi	—	3	7	3	13	9.00	—	—	1	4	5	3	13	90.30

[1] Class limits are inclusive. Averaged on original data.

the eye and under pore 5 of the lateral canal. It opens from the infraorbital canal by a short anterior branch and is frequently absent. Pore 2 opens on a posterior branch which joins the main canal opposite pore 1. Pores 3 and 4 are evenly spaced and directly under pore 2. Pores 5, 6, and 7 are arranged in a line anterior from pore 4 and cross the cheek well below the eye. Pores 8 and 9 lie on the sharp ridge of skin that overhangs the maxillary bone and are well anterior to the main canal. Pore 10 is laterad from the anterior nostril. The P.O.M. canals are not connected to the other canals but join together on the lower jaw in almost all specimens. Each canal consists of ten separate pores, and they share a common eleventh pore (see Robins and Miller, 1957: fig. 3a). Pores 1 and 2 lie above the upper preopercular spine and are always small. All remaining pores are very large. Pores 3, 4 and 5 are close to the three preopercular spines. Pores 6 and 7 form a double pore behind the border of the jaw and lie over the large sensory foramen in the articular bone. Pores 8, 9 and 10 are along the rami of the lower jaw and pore 11 is the common anterior median chin pore.

In addition, there is a remnant of an opercular canal along the vertical anterior edge of the opercle. There are usually two rudimentary pores and a rudiment of a tube in this canal.

Comparisons.—*C. girardi* is most closely allied to *C. carolinae* and its related forms. Of the several forms of that species it resembles the geographically distant *zopherus* most. With *C. carolinae* it shares the following characters: the large head, conspicuously mottled chin, the enlarged palatine tooth patch and its relationship to the vomerine patch, the presence of three well developed preopercular spines, and the narrow bands, (excluding *C. carolinae* ssp. from the Tallapoosa River System of Alabama.) It differs markedly from all subspecies of *carolinae* in having the P.O.M. canals joined, a character which it shares with *C. asper, aleuticus, princeps, ricei* and portions of the complex which masquerades as *C. gobio* in Eurasia. This character is considered primitive in the genus. The presence of a sexually dimorphic anal papilla and the possible presence of a distinctive male breeding coloration clearly separate it from *carolinae*, (except *zopherus*) and, again, suggest a primitive form. In addition, it is readily distinguished from *C. c. carolinae* by its short lateral-line canal, (17–25 pores as compared with 28–37.) *C. carolinae* ssp. from the Kanawha River System of Virginia and West Virginia, geographically its closest relative, has 24–33 lateral-line pores and thus approaches *girardi* in this character. Using the method proposed by Ginsburg (1938) a line of separation drawn between 25

and 26 lateral-line pores gives an average divergence of 95 per cent. Kanawha River populations usually have 17 pectoral rays while *girardi* most often has 15. A line of separation drawn between 15 and 16 pectoral rays will separate almost 95 per cent of the specimens. The irregular borders of the bands of *C. girardi* are in sharp contrast with the clearly defined borders of *C. c. carolinae* but are closely approached by some specimens of the Kanawha River subspecies. The Kanawha form differs markedly in its reduction of chin mottling.

C. girardi differs from members of the *bairdi* species group, (here taken to include *cognatus*) in many of the characters which it shares with *carolinae*, and in the fusion of the P.O.M. canals. It has closely approached populations of *C. bairdi*, from Atlantic drainages of the Middle Atlantic States with which it occurs sympatrically, in numbers of fin rays and lateral-line pores. Indeed, identification by means of fin-ray counts alone is virtually impossible. Probably for this reason early workers overlooked *girardi*. Potomac specimens of *bairdi* usually have 14 pectoral rays but often have 15 so that there is a considerable overlap of the two forms in this, the best fin-ray difference.

Range.—Tributaries of the Potomac River System in Pennsylvania, Maryland, Virginia and West Virginia.

Habitat.—There seems to be no ecological separation between *C. bairdi* and *girardi* in areas where the two occur together; they appear in the same seine hauls in clear water riffles. When the entire Potomac system is considered, however, *bairdi* proves to be restricted to the colder headwater streams while *girardi* seems more adaptable and occurs from the headwaters to the small but warmer downstream brooks.

Discussion.—Due to the absence of descriptions of diagnostic characters and to the similar fin-ray counts of *C. girardi* and *bairdi*, it is impossible to allocate literature references of Potomac specimens. These may apply equally well to *bairdi*, *girardi* or to an undescribed form from the Shenandoah River system which seems related to *cognatus*. Jordan (1889:105) in recording *C. bairdi* from the Potomac, noted "Our specimens correspond to var. *carolinae*, Gill," but he did not elaborate the point. This record may not be allocated with certainty since Jordan did not recognize *carolinae* as a species and his concept of "var. *carolinae*" was based largely on Smoky Mountain populations of the *bairdi* complex.

There has been a tendency to regard fishes restricted to a single river system as endemics. The features of *girardi* which are here regarded as primitive in the group and the absence of related forms in neighboring river systems strongly suggest the opposite view, that it is a relict species.

C. girardi should be added to the list of species similarly isolated in segments of the various river systems from the Patuxent to the Roanoke. Their distributions seem to indicate survival of remnants of an older fauna in river systems peripheral from the active centers of evolution and dispersal west of the Appalachian mountains. Such species are *Etheostoma sellare* (Radcliffe and Welch), *Percina notogramma* (Raney and Hubbs), *Noturus gilberti* Jordan and Evermann, *Moxostoma rhothoecum* (Thoburn), *Moxostoma hamiltoni* (Raney and Lachner) and *Moxostoma ariommum* Robins and Raney. More thorough consideration of these points must await a presentation of data on the entire *C. carolinae* complex which forms a natural group of species.

The species is named in honor of Charles Girard, an early student of the genus.

In the headwaters of the Holston River System of northeastern Tennessee and neighboring portions of Virginia and West Virginia there is today a startling assemblage of sculpins whose very existence depends on the profuse flow of cold spring waters. Several of them became isolated and subsequently differentiated in the long periods between the various glaciations whose cooling effect permitted the ancestral stocks to gain access through channels now far too warm for survival. From the start, this region bade fair to harass any student of the group, an expectation which has been abundantly fulfilled. The redfin sculpins, which includes the mottled sculpin *C. bairdi*, and the northern sculpin *C. cognatus* are especially bothersome although the banded sculpins (the *carolinae* complex) are also not to be overlooked (these groups were briefly discusssed by Robins, 1955). One member of the redfin group is now described.

Cottus baileyi*, *sp. n.

Black Sculpin

(Tables 2, 3, Figs. 1b, c)

Material.—The holotype, CU 25914, an adult male 54.5 mm in standard length was

collected in the Middle Fork of the Holston River, 6 mi. ENE of Marion, Smyth Co., Va., on April 1, 1940 by Edward C. Raney and Ernest A. Lachner. An adult female, CU 25915, 54.4 mm. in standard length taken with the holotype is designated as the allotype. Seventy-five paratypes were collected with the holotype and allotype: CU 22849 (58, 24–64), UMMZ 167171 (17, 27–59). A collection of eggs accompanies the paratypes in the Cornell collection.

Additional material examined but not designated as paratypes:—Va., Smyth Co., CU 24418 (7, 41–66) Mid. Fk. Holston R., 15.6 mi. SW of Wytheville on rt. 11, June 4, 1952. UMMZ 129084 (1, 36) Dickey Cr., 1 mi. S of Sugar Grove, Oct. 14, 1938. UMMZ 129106 (1, 48.6) Bear Cr., trib. Mid. Fk. of Holston R., Oct. 25, 1938. USNM 102433 (1, 55) N. Fk. Hoslton R., 3 mi. S of Sharon Spr. Bland Co., June 5, 1935. CU 19179 (10, 19–54) Laurel Cr., about 2.5 mi. S of Damascus on rt. 91, Nov., 2, 1947.

Tenn., Johnson Co.: CU 21512 (4, 38–54) Trib. Laurel Cr., 1.5 mi. S of Damascus, Va., June 5, 1952. UMMZ 157471 (29, 22–68) Little Doe Cr. 2 mi. above mouth in Roane Cr., just above Hwy 67 at Doeville, Sept. 19, 1947.

Diagnosis.—A small species rarely exceeding 60 mm in standard length (largest 68 mm). Palatine teeth completely lacking. Sexual dimorphism well marked; the breeding males almost entirely suffused with black except for the orange-red border on the first dorsal fin, the females pale-colored, strongly blotched and banded with dark. Pectoral rays modally 15. Counts and measurements of the holotype and allotype (size of body parts expressed in thousandths of standard length); in each instance the first figure applying to the holotype: I-D—7, 7; II-D—17, 17; A—13, 13; P—15–15, 14–15; V—4–4, 4–4; L.L.P.—24, 25; S.L.—54.5, 54.4; L.L.—906, 868; H.L.—323, 324; E.L.—81, 84; C.P.—92, 84; C.F.—253, 252; P.L.—295, 281; V.L.—238, 211.

Description.—Color of breeding males: The base of the first dorsal fin and the entire surface of all other fins are densely covered with melanophores and appear black. The head and entire body is blackish so that the underlying pattern of bands is scarcely discernible. The upper portion of the first dorsal fin is a bright orange-red. The caudal fin is occasionally edged with white. The belly appears lighter than the dorsum but is uniformly covered with melanophores. The anal papilla is enlarged into a flat V-shaped structure that projects to the anal-fin base. Like the rest of the body, it is heavily pigmented with black, at least during the breeding season. The general black coloration of the breeding male is shown in Fig. 1b, a lateral view of the holotype.

Coloration of the female.—Background color is tan or light brown, heavily marked with dark brown. Five dark areas may be seen in dorsal view. The first is a dark square behind the eyes on the occiput. The other four are bands which cross the dorsal surface of the body. The pale-colored nape contrasts sharply with the dark occiput and the most anterior band. This light area forms a broad semicircle as it extends laterally to the upper margin of the opercle and forward to the hind margin of the eye. A large dark band starts at the upper edge of the pectoral base and crosses the back under the entire length of the first dorsal fin. It reaches its greatest width on the midline of the back. The second band crosses the back well behind the origin of the second dorsal fin. Most often it passes under the bases of rays 6–8 but frequently involves rays 5–7. The third band crosses the back near the hind margin of the second dorsal fin. Four rays are involved, usually rays 12–15, less often rays 13–16. The second and third bands are irregular in outline and are mottled on the lower side. The fourth band encircles the base of the caudal fin and the posterior portion of the caudal peduncle. The band widens on the side of the caudal peduncle to form a dark triangular area.

All fins are banded and blotched with dark; the pigment includes both the surface of the rays and the interradial membranes. This contrasts with the *carolinae* complex in which the pigment is almost entirely restricted to the surfaces of the rays.

Four dark lines radiate from the eye and are diagnostic for the female. Anteriorly a dark line passes from the eye through the anterior nasal opening and across the upper lip. While they do not meet, the stripes which extend anteriorly from each eye are convergent and show up in anterior view as a black V, the apex of which is missing. A second dark bar extends from the lower anterior margin of the eye to the hind portion of the upper jaw. It crosses the maxillary and premaxillary but is not continued on the lower jaw. Immediately behind the origin of the second dark stripe, a third stripe begins which extends across the cheek to the ventral margin of the preopercle. The fourth dark stripe passes from the posterior ventral margin of the eye to the main preopercular spine.

The chin in females is somewhat mottled and in this respect resembles a *carolinae* type.

The non-breeding males resemble the females in coloration but are less contrasting in their pattern of bands and blotches. The four radial eye stripes are most often represented by scattered dark spots and, with the exception of the third, are frequently absent.

The anal papilla in females is a very small rounded or trilobed protuberance. Immature and non-breeding males have the anal papilla much reduced but determination of sex by this means is still reliable.

The bases of the dorsal fin are narrowly joined. The depressed dorsal fin reaches to the first upper procurrent caudal ray in females and occasionally onto the caudal fin itself in adult males. The depressed pectoral fin extends beyond the anal-fin origin. A small dark blotch is present on the outer base of the pectoral fin.

There are six branchiostegal rays, four attached to the ceratohyal and two to the epihyal.

The upper preopercular spine is well developed in most specimens although not so large as in *C. carolinae*. In a few specimens the spine is reduced to such an extent that dissection is needed to detect it. The upper accessory spine is usually present but is small and seen only upon dissection. It slopes downward and is hooked forward. A third spine is most often a small protuberance on the preopercle or is completely absent. Rarely is it developed as a small spine which projects downward and forward.

The species is completely naked. All sculpins in the general region of the Smoky Mountains and the upper reaches of the Tennessee Basin have the prickling reduced or absent. This, coupled with the great variability of the character in other river systems, suggests that it is environmentally influenced and caution should be used in evaluating its systematic importance, a suggestion discussed by Robins and Miller (1957).

The development of the lateral line on the head.—The lateral canal consists of five pores, all small. Their arrangement is similar to that described above for *C. girardi*. The supratemporal canal includes three small pores. The supraorbital canal is composed of four pores; a coronal pore, an interorbital pore, a posterior nasal pore and an anterior nasal pore. The arrangement of the pores of the supratemporal and supraorbital canals is similar to that described by Bailey and Dimick (1949:9) in *C. hubbsi*. There are nine infraorbital pores which correspond to pores 2–10 of *girardi*; pore 1 is absent. The P.O.M. canals are separate from the other head canals and each contains 11 pores. The arrangement is similar to that described above for specimens of *girardi* except that two pores are present anteriorly on the chin. The first two pores which lie above the main preopercular spine are very small. The lower nine which are enlarged in other species are small in specimens of *C. baileyi*. Specimens from Laurel Creek differ in having the P.O.M. canals united and a pore count of 10–1–10. Until more material is available it seems best to consider them unusual variants of *baileyi*.

Dorsal, anal, pelvic and pectoral fin-ray counts are given as frequency distributions in Tables 2 and 3. There are modally seven dorsal spines and 15 pectoral rays. Twelve caudal rays attach to the hypural plate, nine of which are branched.

The body is deepest under the first dorsal fin, but like most members of the *bairdi* complex the body is but little arched. The dorsal and ventral surfaces seem almost subparallel for most of their distance. This contrasts sharply with the strongly arching body of *C. carolinae*. The anal opening is directly under the origin of the second dorsal fin. The origin of the anal fin is directly under the base of dorsal ray 3 or between rays 2 and 3 of the dorsal fin. The distance from the tip of the snout to the anal opening reaches nearer to the mid-point of the caudal fin than the caudal base when extended backward. Size of body parts expressed as hundredths of standard lengths are presented as frequency distributions in Table 3.

Comparison and relationships.—*C. baileyi* is clearly a member of the *bairdi* species group. The similarity to other members of the group is most strongly brought out by the marked breeding coloration and the enlarged anal papilla of the male. It is otherwise to be associated with this group in having a reduced preopercular armature, a a reduced palatal dentition, and a uniformly pigmented chin (with the exception of some females, as noted above).

Within the *bairdi* group, its relationships are not clear. This is due, in part, to the overall similarity in meristic features of all members of the complex and to the large geographic variability of the group in other features which seem to distinguish *baileyi* from neighboring populations of *bairdi*. Whenever two members of this complex have come together without interbreeding

they have proved to be ecologically incompatible. Thus, in the north, *cognatus* and *bairdi* live next to each other in many rivers, *cognatus* inhabiting the small cold springs and grassy situations or the colder upstream portions of small creeks while *bairdi* lives in the rocky or somewhat warmer downstream portions of the creeks and rivers. Likewise, both *baileyi* and *Cottus bairdi* ssp. occur in the Holston River. Here, *baileyi* is restricted to a few scattered localities, where it is apparently quite common, while the *bairdi* representative is more widespread through the main course of the stream. The two have not been taken together. The ecologically restricting factors are not known and merit future study.

It is largely on the basis of the undescribed subspecies that *baileyi* is here accorded specific rank. It is perplexing and yet typical of the problems encountered in a study of the genus *Cottus* that the subspecies should be far more divergent in many of its characters from *C. bairdi* than is *baileyi*. Yet it seems connected by intergrading populations while no instance of intergrading or hybridization of *baileyi* and related forms is known. Comparison of *baileyi* and its relative best awaits description of that form. From the nearest populations of *C. b. bairdi*, which occur in the New and Sequatchie rivers, *baileyi* differs sharply in its complete lack of palatine teeth. It differs from all members of the complex in its etxreme development of the black breeding coloration of the male. In this feature it is most closely approached by the geographically distant *C. cognatus*.

C. baileyi and *C. c. carolinae* occur sympatrically at least in the Middle Fork of the Holston River. The two may be separated by the following features (in each instance the first condition applies to *carolinae*): (1) a well developed palatine tooth patch which exceeds in its length the greatest dimension of the vomerine patch vs. no palatine teeth; (2) three strongly developed preopercular spines vs. one well developed spine; (3) no enlargement of the anal papilla in males vs. a large triangular anal papilla in males; (4) no coloration peculiar to breeding males vs. a striking male breeding coloration; (5) size large, commonly exceeding 100 mm in standard length vs. size rarely in excess of 60 mm; (6) lower surface of the head strongly mottled vs. uniform; (7) dorsal profile strongly arched vs. flattened; (8) lateral line complete, usually containing 31–34 pores vs. lateral line usually incomplete, containing most often 24–26 pores; (9) modally 16 or 17 vs. 15 pectoral rays; (10) dorsolateral bands widely separated and narrow vs. dorsolateral bands wider, their combined width exceeding the distance between them; (11) pigmentation on interradial membranes generally lacking vs. generally present.

Range.—*C. baileyi* is locally distributed in the four main branches of the Holston River system; the North, Middle and South Forks of the Holston River proper and the Watauga River.

Habits.—Specimens collected on April 1, 1940 in the Middle Fork of the Holston River (CU 22849, CU 25914, 25915; for data see above) by Raney and Lachner (ECR 709) were in full breeding condition. Several egg masses were collected in riffles. The eggs are arranged in three definite tiers although the three tiers are by no means of equal extent. Only one of the egg masses was intact. This contained about 70 eggs; the exact number was not determined since it seemed desirable to leave the mass complete. Two females which had not laid were dissected. The first, 48.2 mm in standard length had 38 eggs in the left ovary, 39 in the right for a total of 77 eggs. The second, 60.2 mm had 38 eggs in each ovary for a total of 78 eggs. All of the eggs were equally developed and fully as large as those in the collected egg masses. Mature ovarian eggs average 3.4 mm in diameter, those from the egg cluster about 3.6 mm. This small difference may be due entirely to differential shrinkage in alcohol and formalin in which they were respectively preserved. The gut in these specimens was reduced to a thin ribbon and the stomach and other organs displaced far forward in the body cavity. It seems unlikely that food could be taken at this time. A third female 43.2 mm in standard length, had 23 eggs in the right ovary and 18 in the left. Some, although not many, had been shed from the left ovary. The suggestion is that one ovary is emptied before the eggs are shed from the second ovary. No eggs remained in the body cavity of several spent females. The correlation between the number of eggs observed in a laid cluster, the number of eggs in a mature female, and the absence of half-spent individuals suggest that all eggs are laid at the same time.

Eight specimens of *C. c. carolinae* (CU 9942) were collected with the breeding series of *baileyi*. An examination of the gonads of these specimens shows that both the ovarian eggs and the testis are very small, so that the two species probably breed at different seasons of the year.

Name.—The species is named for Dr. Reeve M. Bailey of the University of Michigan Museum of Zoology in recognition of his many noteworthy contributions to our knowledge of North American freshwater fishes.

Summary

Two new species of sculpins, *Cottus girardi* and *C. baileyi* are described. The former is a primitive representative of the *carolinae* complex and is restricted to the Potomac River system of Pennsylvania, Maryland, Virginia and West Virginia. The latter, a member of the *C. bairdi-cognatus* complex, is isolated in the headwaters of the Holston River in Tennessee and Virginia.

Literature Cited

Bailey, R. M. and Mary Fitzgibbon Dimick. 1949. *Cottus hubbsi*, a new cottid fish from the Columbia River system in Washington and Idaho. *Occ. Pap. Mus. Zool. Univ. Mich. 513:1–18, 1 pl. 1 map.*

Hubbs, C. L. and K. F. Lagler. 1947. Fishes of the Great Lakes region. *Cranbrook Inst. Sci. Bull. 26, i–xi, 1–186, 251 figs. 26 col. pls. 1 map.*

Hubbs, C. L. and M. D. Cannon. 1935. The darters of the genera *Hololepis* and *Villora*. *Misc. Publ. Mus. Zool. Univ. Mich. 30:1–93, pls. 1–3.*

Robins, C. R. 1955. A taxonomic revision of the *Cottus bairdi* and *Cottus carolinae* species groups in Eastern North America (Pisces, Cottidae). *Dissertation Abstracts, 15(2):302–3.*

Robins, C. R. and R. R. Miller. 1957. Classification, variation, and distribution of the sculpins, genus *Cottus*, inhabiting Pacific slope waters in California and Southern Oregon with a key to the species. *Calif. Fish and Game, 43(3):213–33, 3 figs.*

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Variation and Distribution of *Desmognathus ocoee* Nicholls (Amphibia: Plethodontidae)

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Within the large salamander genus *Desmognathus* two similar species have remained relatively unmentioned in herpetological literature. These are *D. ocoee* Nicholls (1949) and *D. perlapsus* Neill (1950).

The discovery of salamander populations with characteristics similar to both *ocoee* and *perlapsus* has prompted me to examine topotyptic and other material of these species, and also to read more critically their original descriptions. The results of these investigations follow; they are based upon the study of 349 specimens from four states.

History

The two original descriptions are cited above. Besides these, Nicholls (1950, 1953) has discussed the salamander species associated with *ocoee* and described its habits. Eaton (1954) recorded *perlapsus* in North Carolina and figured the larva. Blair (1957) included the two in his key to the species of *Desmognathus* and gave brief diagnoses. Conant (1958) discussed the two briefly, mapped the three known localities, and illustrated *perlapsus*. With the exception of checklists and casual mention, this appears to be the entire bibliography of these two salamanders.

Relation of *ocoee* to *perlapsus*

Desmognathus ocoee Nicholls was described (p. 127) from "a series of 28 adult specimens collected on the surface and in crevices of cliffs at Ship's Prow Rock, in Ocoee Gorge, beside U. S. Highway 64, nine miles airline west of Ducktown, in Polk Co., Tennessee." I first collected the species in Ocoee Gorge on September 3, 1947, but on September 5, when I was accompanied by Mr. Nicholls, the cliff was dry and no specimens were seen. In April, 1951, I revisited the spot, found the cliffs wet, and collected topotypes and many additional specimens over a distance of nine miles along the Ocoee River Gorge. The habitat is a remarkable one inasmuch as specimens can be found only at scattered spots where the cliff face is provided with deep cracks and is wet with seepage. The cracks are necessary for the salamanders retreat into them during daytime and dry periods. Because *ocoee* will not cross a dry expanse of cliff, and even in rainy weather rarely appears to venture far from its home crevice,

the various seepage inhabiting populations are semi-isolated. The result is that no two populations are exactly alike, and some are quite different from adjacent ones. By sheer chance, the Ship's Prow Rock population (the only one known when the species was described) is the most aberrant and atypical of the lot. The bright pattern of topotypic *ocoee,* the feature that gives the species its remarkably distinctive facies, becomes much duller and less exaggerated as one moves eastward along the Gorge. The basic topotypic pattern and its variations were described accurately and in detail by Nicholls (1949: 127). Other populations along the Gorge show varying amounts of fusion of the dorsal spots and different degrees of darkness. See Figure 4.

Desmognathus perlapsus Neill was described (1950:1) from eighteen specimens collected on "a rocky outcropping on the western wall of Tallulah Gorge, near the town of Tallulah Falls, Rabun County, Georgia." Detailed instructions for reaching the exact spot were given by Neill (p. 6). Since the species is also a cliff-dweller and was described from a single seepage, it is to be expected that colonies will differ slightly from one another, and therefore that the intraspecific variation will be increased when additional populations are examined.

In comparing *perlapsus* with other species of *Desmognathus,* Neill (p. 5) stated that it and *ocoee* agree in being cliff-dwellers, in tail shape, in having wide black margins around the pale dorsal markings, and in having white flecking on the upper surfaces and whitish mottling on the sides and venter. He then listed seven features in which the two differ, these being that *ocoee* is smaller, has a proportionately shorter and narrower head, relatively longer limbs, no vomerine teeth in adult males, roughly oblong parasphenoid tooth patches instead of long slender patches, more sharply defined dorsal pattern, and five to six pairs of spots instead of four forming the dorsal pattern between the axilla and groin. Each of these seven features is discussed below. The comparison is based on 105 specimens of *ocoee* from the Ocoee River Gorge, of which 22 were from Ship's Prow Rock, and 70 specimens of *perlapsus* from Tallulah Gorge, of which 24 have been compared superficially with the series of paratopotypes in Neill's collection.

Neill's statement that *perlapsus* is larger than *ocoee* holds in the material at hand. For the largest *ocoee,* Nicholls gave approximately 34 mm. snout to vent, and Blair (1957: 227) 32 mm. My largest is a 37 mm. topotype. For *perlapsus,* Neill cited 40.4 mm., and Blair stated not over 40 mm. The largest *perlapsus* from Tallulah Gorge in my material has a snout-vent measurement of 42 mm., and 16 specimens, all males, exceed the 37 mm. maximum for *ocoee.* There is, however, a distinct possibility that *ocoee* exceeds 37 mm. for I have an impression that the largest specimens were not obtained. When collecting, it is easy to miss large adults for, unlike the smaller specimens that wander about freely on the rock surfaces, the largest usually remain in cracks and crevices with just their heads showing. They retire at the least disturbance, even a flashlight beam often being sufficient cause. Large specimens of *perlapsus* were obtained simply because the cracks into which they retreated were shallow enough to permit use of a short piece of wire to tease them out; this technique was impossible in Ocoee Gorge due to the depth and extent of the crevices there. A second reason for believing that size is not yet a proven difference between the two forms is the sub-maximum appearance of male *ocoee* due to the absence of the dark pigmentation normally characteristic of their sex. This darkening and obscuring of the dorsal pattern is very conspicuous in larger specimens of *perlapsus* and in the other populations discussed below. The fact that Neill's male holotype was clearly spotted is explained by its size, being only 38.6 mm. snout-vent. The largest *ocoee* male is 36 mm. and is, of course, spotted; despite the spots, this individual is appreciably darker than smaller specimens, and therefore suggests that when larger specimens are collected, heavy pigmentation will be found to be a feature of *ocoee* too. An excellent example of the difficulty inherent in collecting maximum sizes is afforded by Eaton (1954:42) who stated that his 28 topotypes of *perlapsus* had a maximum snout-vent length of only 38 mm.; nine days later in North Carolina, the largest specimen of 41 individuals was 31 mm. He commented on the absence of the larger size class, and mentioned that larger specimens were seen, but could not be collected.

Desmognathus ocoee and *perlapsus* were also said to differ in head proportions; that of *perlapsus* being longer and broader. Table 1 shows a comparison of snout-vent length over head length (SV/HL) ratios and also

of snout-vent length over head width (SV/HW). The difference between the SV/HL ratios for large *perlapsus* in Dr. Neill's and my material are unexplained, unless some effect of fixation is at work. In equivalent sized, uniformly preserved material the two forms overlap in both ratios.

Desmognathus perlapsus was also supposed to have shorter limbs, as expressed in the number of intercostal spaces between appressed toes, the shorter the legs, the higher the intercostal space count. Concerning this feature, Nicholls (1949:127) counted two, rarely three for *ocoee*; Neill (p. 2) counted about four and one half for the type of *perlapsus* and did not discuss variation. On the other hand, Blair (1957:228, 9) counted three to four spaces in *ocoee* and one to three in *perlapsus*. My data support Blair, except that *perlapsus* usually has two to three rather than one to three spaces. Figure 1 shows this for all transformed Ocoee Gorge *ocoee* and Tallulah Gorge *perlapsus* studied. These specimens *were preserved in identical fashion* and demonstrate that *perlapsus* actually shows a slight tendency to have longer rather than shorter legs. The differences between the data presented by Neill and Nicholls, and between theirs and mine, are possibly due to fixation techniques. Neill's statement might be a typographic error, for his illustration (p. 3) of the holotype of *perlapsus* clearly shows a long-legged salamander with less than four and one half intercostal spaces. It is well known, but worth repeating, that the number of intercostal spaces between appressed toes tends to increase with greater snout-vent lengths; apparently the legs grow more slowly than the body. This can be seen in Figure 2 which correlates intercostal spaces with snout-vent lengths for 100 specimens of *ocoee*. Workers who use this characteristic should be careful to state snout-vent lengths of the material described.

Vomerine and palatine (parasphenoid) teeth were also cited as means of separating *perlapsus* and *ocoee*. Nicholls (p. 128) stated that vomerine teeth are absent in adult males of *ocoee*, and that the palatine tooth patches are roughly oblong, about four times longer than broad. For *perlapsus* Neill stated (p. 1, 2) that vomerine teeth were present in all specimens, and that the palatine patches were very long and slender. An examination of the six largest males of each species shows that all lack vomerine teeth. In *perlapsus* there sometimes is a transverse bony ridge on each vomer marking where the teeth once were.

TABLE 1. SNOUT-VENT/HEAD LENGTH AND SNOUT-VENT/HEAD WIDTH RATIOS FOR THREE POPULATIONS OF *Desmognathus*. DATA ON PARATYPE *D. perlapsus* FROM NEILL (1950)

	SV/HL range and mean	SV/HW range and mean
8 Largest ocoee 35–37 mm.	3.0–4.4 (3.9)	4.7–5.8 (5.3)
12 Perlapsus 35–37 mm.	3.4–4.3 (3.8)	4.5–6.2 (5.0)
6 Paratype perlapsus ?–40.4 mm.	3.2–3.4 (3.3)	4.5–4.8 (4.7)

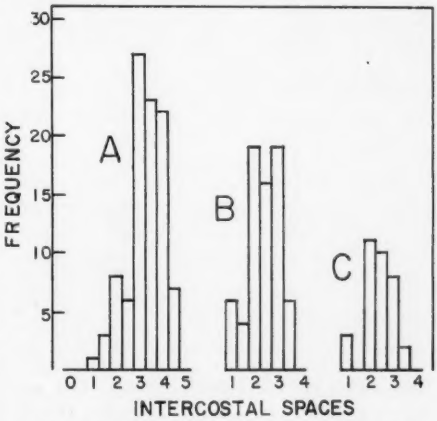

Fig. 1. Intercostal spaces of three ponulations of *Desmognathus*. A from Ocoee Gorge; B from Tallulah Gorge; C from Long Island Gorge.

This is easily mistaken for a row of close-set teeth, especially if the specimens are wet. The ridge is absent in some individuals; perhaps it is slowly absorbed after the teeth are lost. The retention of teeth in Neill's series might be due to their smaller size, or to local variation. An excellent example of the latter is afforded by the microgeographic subspeciation of *Leurognathus marmorata* in which three different vomerine tooth arrangements are distributed among five neighboring populations (Martof, 1956). Males of *perlapsus* without vomerine teeth may be as small as 31 mm. snout-vent. On the other hand, the largest male that retained teeth was 36 mm. However, these figures will probably be expanded when more material is examined.

The palatine tooth patches are also invalid characters for separating the two "species." Both forms are extremely variable.

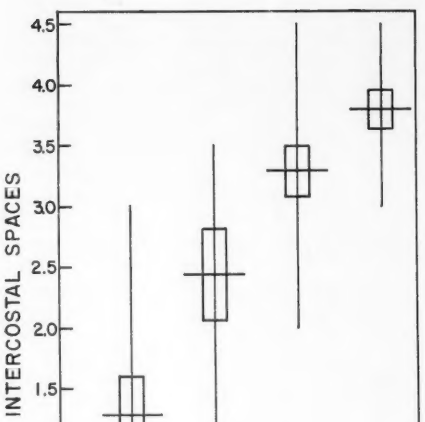

Fig. 2. Number of intercostal spaces in 100 *Desmognathus ocoee* arranged in four groups of progressively greater snout-vent length. In each group the vertical line represents the range; the horizontal line the mean; and the rectangle plus and minus twice the standard error of the mean.

Large males of *ocoee*, described as having patches 4 times longer than broad, actually vary from 4 to 7.5 times longer than broad; *perlapsus* is almost identical, large males having the length of the patches varying from 4 to 8 times the width.

Desmognathus ocoee was described as having a much more sharply defined dorsal pattern, with ten or twelve spots between the leg insertations, while *perlapsus* is duller, and usually has eight spots. As remarked earlier, the clear pattern of topotypic *ocoee* is not characteristic of the species. Figure 4 shows eight *ocoee* topotypes, eight specimens taken 0.4 miles east of the type locality, and eight specimens from 3.5 miles east of the type locality. The relative distinctness or dullness of pattern is a local population characteristic. The same comment may be made for the number of spots between limb insertions. Figure 3 compares this feature in the two forms. The isolation and resultant inbreeding in these salamanders makes each population somewhat different, thus, in part, explaining the preponderance of eight-spotted individuals in Neill's material and their rarity in mine. However, eight is not necessarily a feature of topotypic *perlapsus*. Eaton (1954:41), who collected 28 topotypes at the exact spot described by Neill, stated, "The range of variation in . . . *perlapsus* was greater than I had expected from Neill's paper, which, however, was based on a smaller number of specimens"; two pages later, Eaton further remarked that "The pattern and color are highly variable . . . *perlapsus* frequently (but by no means always) shows four pairs of spots on the back between fore and hind limbs . . ."

It is evident from the data just presented that none of the seven features used to distinguish *Desmognathus ocoee* and *perlapsus* are discriminatory at either specific or subspecific levels. As the younger name, *D. perlapsus* is therefore a synonym, the species being *Desmognathos ocoee* Nicholls.

Relation to Other *Desmognathus*

Nicholls (1949:129) postulated that *D. ocoee* had affinities with *D. ochrophaeus carolinensis* Dunn, and Eaton (p. 43) agreed. Neill (p. 5), discussing Tallulah Gorge material, implied a position intermediate between *carolinensis* and *D. fuscus fuscus* (Rafi-

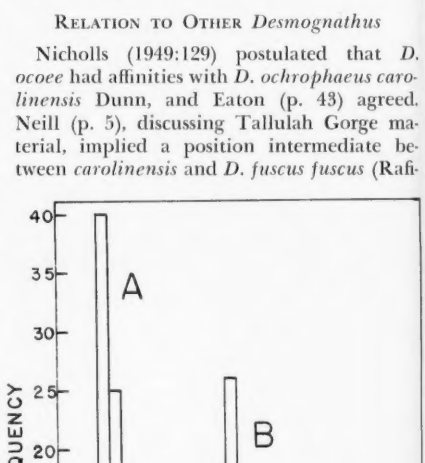

Fig. 3. Number of dorsal spots between fore and hind limb insertions in three populations of *Desmognathus*. A from Ocoee Gorge; B from Tallulah Gorge; C from Long Island Gorge.

nesque) and favored *fuscus* as the closer of the two. His position is based on general facies and the tendency for *ocoee* to possess a low keel on the tail. The low caudal ridge is an obvious feature of *ocoee* and does seem to imply a relationship with *fuscus*; however, it has been remarked that low altitude specimens referred to *D. o. carolinensis* are unusual in that they too sometimes possess a faint keel. For example, Dunn (1926:113) cites it indirectly as one of the reasons for considering *carolinensis* a subspecies of *fuscus*, rather than of *ochrophaeus*. Tail shape, then, can be used to indicate relationship of *ocoee* with either low altitude *carolinensis* or *fuscus*. Typical *ocoee* and *carolinensis* are also similar in the sinuate jaws of males and the broken color patterns. *Desmognathus fuscus* differs from both by its heavier build, more strongly keeled tail, nonsinuate jaw commissure, and color pattern. I believe it can be ruled out as a very close relative of *ocoee*, but as Neill said, there is evidence of some relationship between the two. With regard to color pattern, it should be remembered that *fuscus* varies clinally from north to south, and specimens from the area where *ocoee* occurs usually show a broad, sharply angled, zigzag, dorsal stripe quite different from the circular edged or spotted patterns typical of *ocoee*. The species overlap slightly in this feature, so it must be used in conjunction with others.

Because of the similarities mentioned above, *ocoee* appears to be the low altitude stock from which montane *carolinensis* was derived. However, the problem of relationship between *ocoee* and *carolinensis* is not simple. The type locality of *carolinensis* is the top of Mt. Mitchell, North Carolina, which, at an altitude of over 6,600 feet, is the highest point in eastern United States. Salamanders from the top of Mt. Mitchell can hardly have the same adaptations, requirements, and physiology as those from Ocoee Gorge; as a result, the two populations can never be synonymous in the biological sense. Taxonomically or nomenclaturially, the problem cannot be settled until the whole *ochrophaeus* complex is studied with care. It is hoped that such a study will soon be made, but until this is done, a change in status for *ocoee* is undesirable, for its correct name depends upon whether or not *ochrophaeus* and *carolinensis* are specifically or subspecifically separate. Despite the unanimity of current literature, this relationship has not yet been satisfactorily established.

There is also a population of *ocoee* which throws light on the origin of all of the *ocoee-ochrophaeus* complex. Although recorded only from single stations in Tennessee, Georgia, and North Carolina, *ocoee* also occurs in extreme northeastern Alabama, and it was an attempt to identify Alabama specimens that prompted the present study. This population was discovered in 1951 by my friend Mr. Charles B. Segars who showed me the first specimens collected. On April 7 of that year, Mr. Segars took me to the collection site in Jackson County at Long Island Gorge, about three miles southwest of Higdon, where, in wet cliff crevices and talus, we collected 34 specimens for my studies plus others for the University of Alabama Collection. These specimens match *ocoee* in most features, see Figures 1 and 3. They differ in maximum size, oral commissure, and color pattern. In size, Alabama specimens are larger than any others, reaching a maximum snout-vent length of 45 mm. However, this largest individual was regurgitated by a *Gyrinophilus*, and being dead and partially digested, possibly did not shrink as much in preservative as the remainder of the series. The next largest individual was 43 mm., and of the 34 Alabama specimens, ten exceeded 40 mm., while only one of 70 Tallulah Gorge *ocoee* was over that size.

The color pattern in this series is often partially or completely obscured by dark brown pigment. When visible, the spots are dark-bordered and resemble those of Tallulah Gorge specimens, except that they are smaller and thus look farther apart. The interspaces are usually wider than the diameter of the individual spots in the Alabama material, while the reverse is more characteristic of Tennessee and Georgia salamanders in which the spots are often closer together or fused to form an irregular stripe. On the other hand, a large series of *ocoee* from Macon Co., North Carolina, although small (maximum SV 35 mm.), shows similar patterns in which the dorsal spots are small and widely spaced. Pattern variation is a strictly local phenomenon.

The oral commissure, or line of junction of upper and lower jaws, is straighter in Alabama males than in any others. Neill specifically mentioned this feature (p. 2), remarking on its sinuosity. In Tennessee and Georgia males, the upper jaw is strongly notched anterior to the eyes, and convex between the notch and the junction with the mandible. In Alabama material, the feature

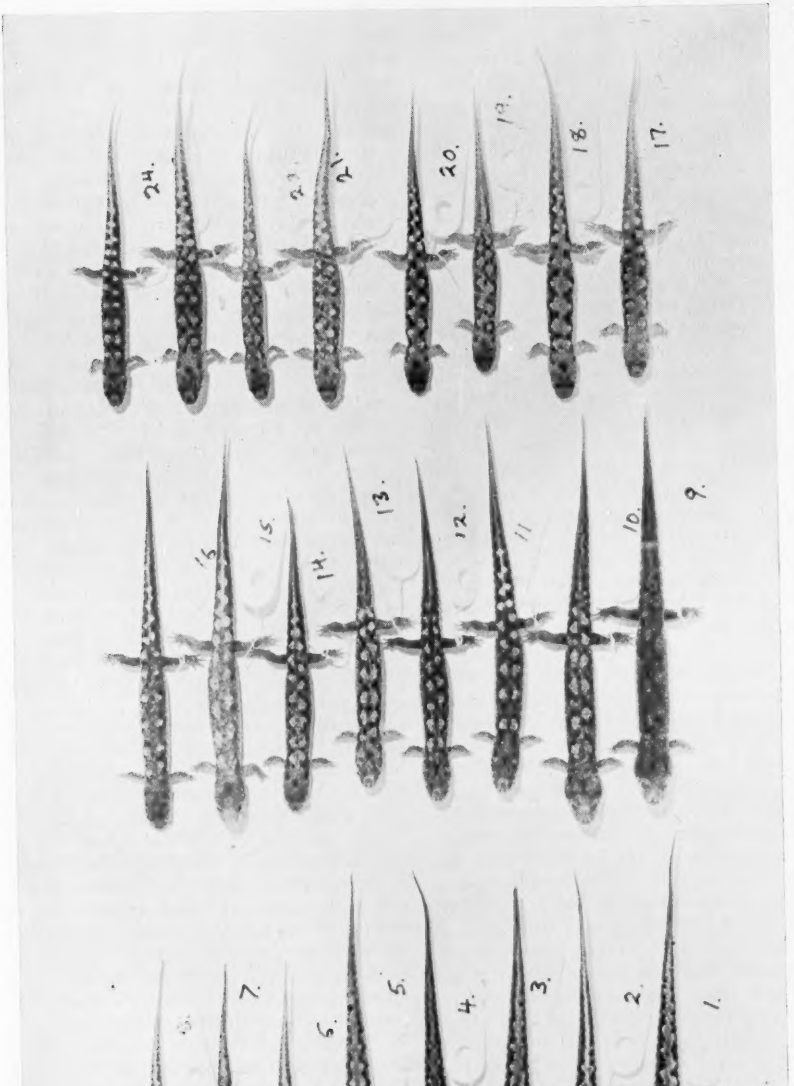

Fig. 4. *Desmognathus ocoee* Nicholls from Ocoee River Gorge, Polk Co., Tennessee. Top row: topotypes from Ship's Prow Rock. Center row: 0.4 miles east Ship's Prow Rock. Bottom row: 3.5 miles east Ship's Prow Rock.

is present but not nearly as exaggerated as elsewhere.

Alabama specimens also seem to have the strongest caudal ridge within the *ochrophaeus*-complex, but they are still referable to *ocoee*. They do show a few dissimilarities but, in the present state of our knowledge, I do not think a separate subspecies is justified. The most telling difference, the straighter oral commissure, is weaker than it appears, for two male salamanders from Dawson County, Georgia, given to me by Mr. Robert L. Humphries (RLH), are intermediate in this feature between the Alabama and Tallulah Gorge series. These two specimens (RLH-A-1107 and 1108) have dorsal color and pattern like topotypic *ocoee*, except that they are slightly browner. Three smaller specimens taken at the same time and place (RLH-A-1099, 1100, 1101) look similar to Neill's type, except that instead of 8 dorsal spots, two have 10 and the third has 12.

Since *ocoee* retains more of the spotted larval pattern than *carolinensis*, and also has a more consistently keeled tail, it probably is closer to the ancestral type from which the entire *ochropheus* complex evolved. If this reasoning is continued, the Alabama *ocoee* are even more generalized, for they are the most consistently spotted, have the best developed caudal ridge, and have the least jaw sinuosity. In each of these three features they show evidence of common ancestry with low altitude members of the *fuscus*-complex (*D. fuscus*, and its "subspecies"). The idea that the *ochrophaeus*-complex was derived from the *fuscus*-complex is not new, but the wide gap has been partly bridged by Alabama *ocoee*, thus changing previous conjecture to the status of a theory based upon positive but still incomplete data.

Distribution

Desmognathus ocoee Nicholls has been reported from only three stations. A summary of the distribution data presented above, plus other specimens, is therefore presented. All material, totalling 349 specimens, is in my personal collection, and unless otherwise stated was collected by myself.

Alabama.—Jackson Co., Long Island Creek (Dry Creek), just below rim of Long Island Gorge (3 miles S.W. of Higdon).

Georgia.—Dawson Co., Amicalola Falls State Park x-28-52 (R. L. Humphries) 5 specimens RLH-A-1099–1101, 1107, 1108. *Rabun Co.*, Tallulah Gorge, just below U. S. route No. 23 bridge.

Tennessee.—Polk Co., "Ship's Prow Rock," 2.7 miles W. of Ocoee River Powerhouse No. 2 on U. S. Route No. 64; 2.3 miles W. of Ocoee No. 2; 0.2 miles W. of Ocoee No. 2; 0.2 miles E. of Ocoee No. 2; 0.8 miles E. of Ocoee No. 2; 6.7 miles E. of Ocoee No. 2, all iv-15-51. [These localities are respectively 0.4, 2.5, 2.9, 3.5 and 9.4 miles east of the type locality]. 0.8 miles E. of Ocoee No. 2; 2.7 mi E. of Ocoee No. 2; 6.0 miles E. of Ocoee No. 2, all iv-29-51. [These localities are respectivity 3.5, 5.4, and 8.7 miles east of the type locality]; 16.2 miles W. of Ducktown, on U. S. No. 64.

North Carolina.—Macon Co., 1.9 miles N.W. of Dry Falls Parking area, on U. S. No. 64, near Gneiss; 5.5 miles N.W. of Dry Falls Parking area, ele. 3150′, both vi-16-52. *Jackson Co.*, Whiteside Cove, east of Highlands vi-28-51. I have also collected the species at Bridal Veil Falls, just northwest of Highlands, Macon County, but the specimens were lost. Eaton (1954) records the species from Transylvania Co., SW. face of Cold Mt., about 5 mi. W. village of Lake Toxaway.

All known records except the Alabama locality fall within the Blue Ridge Mountains Physiographic Province. The Alabama site is in the Cumberland Plateau section of the Appalachian Mountains and separated from the Blue Ridge by the Valley and Ridge Physiographic Province. Specifically, Long Island Gorge in Alabama is on the northwestern slope of Sand Mountain, and the creek which trickles across the top plunges down the side directly into the Tennessee River below. Just how *D. ocoee* got to Alabama is not yet clear, but the problem might be solved by careful collecting in the "Armuchee Ridges" of northwestern Georgia. These ridges are 1400′ to 1500′ in elevation, and occur between LaFayette and Calhoun. They are isolated in the Valley and Ridge, material from them would be of the greatest interest.

The range of *D. ocoee* is sympatric with that of *D. fuscus*, although the two are ecologically separate. On the other hand, *ocoee* and *D. o. carolinensis*, although primarily Blue Ridge forms, appear to be allopatric, as the latter is a form of higher elevations.

The distribution, especially southward, of *D. ocoee* is still incompletely known. It is therefore premature to discuss the geographic history of the complex. However, it should be noted that the Santee and Savannah rivers on the Atlantic side, and the Applachicola and Alabama rivers in Gulf

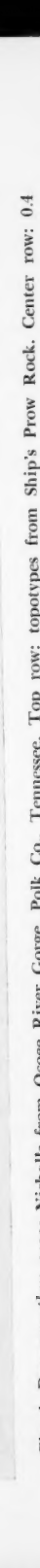

Fig. 4. *Desmognathus ocoee* Nicholls from Ocoee River Gorge, Polk Co., Tennessee. Top row: topotypes from Ship's Prow Rock. Center row: 0.4 miles east Ship's Prow Rock. Bottom row: 3.5 miles east Ship's Prow Rock.

drainage, all originate in the region inhabited by *ocoee*, and that *ocoee* itself now inhabits relatively low altitudes. *D. fuscus* is known to extend coastward along these drainages; perhaps *ocoee* does also. Certain small coastal specimens, currently referred to *fuscus* because of their keeled tail, are suggestive, but the data are still too inconclusive to merit extended discussion.

Summary

1. *Desmognathus ocoee* Nicholls and *Desmognathus perlapsus* Neill are synonyms, the prior name being *D. ocoee*.

2. Within its genus, *Desmognathus ocoee* is most closely related to *D. ochrophaeus carolinensis* Dunn. This conclusion is based on similarities of color pattern, tail shape, and sinuosity of oral commissure.

3. *Desmognathus fuscus* (Rafinesque) is more distantly related, but is approached in all features by the Alabama population of *ocoee*.

4. It is theorized that the *ochrophaeus* complex evolved from the *fuscus* complex via *ocoee*.

5. The distribution of *D. ocoee* is still incompletely known, although now recorded from North Carolina, Tennessee, Georgia, and Alabama.

6. Except for the latter state, records are from lower altitudes in the southern end of the Blue Ridge Physiographic Province.

7. *Desmognathus ocoee* might be found in coastal plain areas.

Literature Cited

Blair, A. P. 1957. Amphibians *in* Blair, W. F., Blair, A. P., Brodkorb, P., Cagle, F. R., and Moore, G. A., Vertebrates of the United States. New York. *McGraw-Hill Book Company, Inc. p. 211–71, fig. 1–75.*

Conant, Roger. 1958. A field guide to the reptiles and amphibians, ...etc. *Boston, Houghton Mifflin Company. 366 p.*

Dunn, E. R. 1926. The Salamanders of the Family Plethodontidae. *Smith College Fiftieth Anniversary Publication 7:441 p.*

Eaton, T. H., Jr. 1954. *Desmognathus perlapsus* Neill in North Carolina. *Herpetologica 10: 41–43, fig. 1.*

Martof, Bernard. 1956. Three new subspecies of *Leurognathus marmorata* from the Southern Appalachian Mountains. *Occ. Papers Mus. Zool. Univ. Michigan 575:1–14, pl. 1–4, table 1, map 1.*

Neill, W. T. 1950. A new species of salamander, genus *Desmognathus*, from Georgia. *Publ. Res. Div. Ross Allen's Reptile Inst. 1:1–6, fig. 1.*

Nicholls, J. C., Jr. 1949. A new salamander of the genus *Desmognathus* from east Tennessee. *J. Tenn. Acad. Sci. 24:127–129.*

———. 1950. Notes on salamanders associated with *Desmognathus ocoee* Nicholls. *Ibid. 25: 310–314.*

———. 1953. Observations on the habits of the salamander *Desmognathus ocoee* Nicholls. *Ibid. 28:118–120.*

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Studies with Cooling Measures Following Injection of *Crotalus* Venom

Jerry A. Emery and Findlay E. Russell

THE use and misuse of cooling measures—icing, refrigeration, hypothermia, cryotherapy, crymotherapy and freezing—in snake venom poisoning have been discussed by a number of investigators[1]. In a previous paper, Russell (1960a) reported that the application of ice bags to the envenomated extremity resulted in a decrease in the amount of edema, or a slowing in the rate of advancement of the edema. This observation was based on a study of 48 cases of rattlesnake venom poisoning, in 19 of which the injured part was maintained at 12° C. Subsequent observation in 7 reported cases (Russell, 1960b) and in 19 unreported cases, tends to confirm the authors' impression that the local application of cooling measures decreases the extent and progression of edema produced by rattlesnake venom.

The opinion was also expressed that cryotherapy has had no effect on the mortality rate from rattlesnake bites in Southern California (Russell, 1960a). This observation is in part supported by the work of Allen (1938), and more recently by the present au-

[1] Allen, 1938, 1939, 1949; Andrews, 1953; Anonymous, 1947; Crum, 1906; Efrati and Rief, 1953; Haw, 1907; Orndoff, 1915; Parrish, 1957; Stahnke, 1954, 1957; Tenery and Koefoot, 1955; Watt, 1954; Willson, 1908; Wood, 1956.

thors in a study on mice which were subjected to cryotherapy in a manner similar to that advised for human beings (Stahnke, 1953). In this study, the left legs of 25–30 gm. Swiss albino mice were shaved, and various amounts of *Crotalus adamanteus* venom dissolved in 0.03 ml. of saline were injected into the superficial muscle layers of the leg. A ligature was placed 1.0 cm. above the site of injection, and the animal placed in a plastic tube in a manner that allowed the envenomated leg to be drawn into an ice filled chamber. The ligature was removed after 5 or 10 minutes, and the leg maintained in the ice bath for one to 2 hours. Body temperature was measured with a thermister placed in the rectum and was maintained with an external heat source. The subcutaneous temperature of the leg in the ice bath was 3–6° C.

It was found that the intramuscular LD_{50} of this venom in a control group of animals was 19.04 (15.61 to 23.23) mg./kg. of test animal body weight. The LD_{50} was increased to an LD_{99} when the envenomated limb was subjected to the ligature-cryotherapy procedure, while the MLD was increased to an LD_{87}. It was felt that the mice receiving ligature and cryotherapy showed less evidence of tissue destruction than those not subjected to these measures, although no objective study was made of the difference.

The present study was initiated to determine the influence in mice of activity, excision, and cooling measures on the LD_{50} of *Crotalus adamanteus* venom.

Material and Methods

Three hundred eighty-four Swiss albino mice, weighing between 25 and 35 gm. were given an LD_{50} of *Crotalus adamanteus* venom in the subcutaneous tissues of the distal third of the tail, and were equally divided into 6 groups for treatment as follows: Group I No therapy. Group II Amputation of tail 1, 2 or 3 hours following injection. Group III Amputation of tail after 1, 2 or 3 hours restricted activity. Group IV Ice bath about tail and restricted activity with amputation at 1, 2 or 3 hours. Group V Ice bath about tail and restricted activity for 1, 2 or 3 hours. Group VI Activity restricted for 1, 2 or 3 hours following injection.

The temperature of the ice bath was held at 2° C. Restriction was assured by placing the mouse in a tight fitting plastic test tube plugged with a cork through which only the tail protruded. Body temperature was maintained with a heat lamp. The animals were observed for 24 hours and their death times recorded.

Results

Figure 1 shows the percent of mice alive at the end of the 24 hour period.

Neither restricted movement, ice bath and restricted movement, amputation at 2 or 3 hours nor restricted movement with amputation at the end of 3 hours, influenced the mortality rate. The animal's chances for survival increased approximately 12 percent when the tail was amputated within 2 hours following the injection, provided activity had been restricted. Survival rate increased when the tail was severed one hour following the injection, and was even greater in those animals in which activity was restricted during the hour prior to the amputation. A mouse whose activity was restricted and whose tail was amputated following an hour in the ice bath, had a 100 percent chance of survival. The survival rate decreased with the passing of time so that by the end of the third post-injection hour it was 84 percent.

Discussion

It is well known that the action of a drug can be influenced by the temperature of the test animal (Fuhrman, 1946). Some substances are more toxic to animals at 20° C. than they are to animals at 0° C. On the other hand, the opposite can also be true. Wiener (1956) has shown that the lethality of *Latrodectus hasseltii* venom is 100 times greater in mice kept in an environment at 0° or 37° C., than mice kept at 18°–24° C. Bata and Vukobratovic (1958) have demonstrated that mice exposed to total body hypothermia are more prone to die from *Toxinum viperae ammodytes* venom, than mice not exposed to this procedure. Micheel and Jung (1936) have noted the importance of maintaining the environment between 23°–24° C. when assaying cobra venom in mice. Other workers have discussed the influence of temperature on the lethality of venoms and toxins (Grasset and Zoutendyk, 1931; Ipsen, 1951; Jovanovic and Katic, 1956; Slotta and Szyszka, 1937).

Bruneau and Heinbecker (1944) have demonstrated that while cooling to 6° C. limits the inflammatory response caused by *Streptococcus hemolyticus,* removal of the cooling source results in the development of a more marked inflammatory reaction with a decrease in the growth restricting power of the

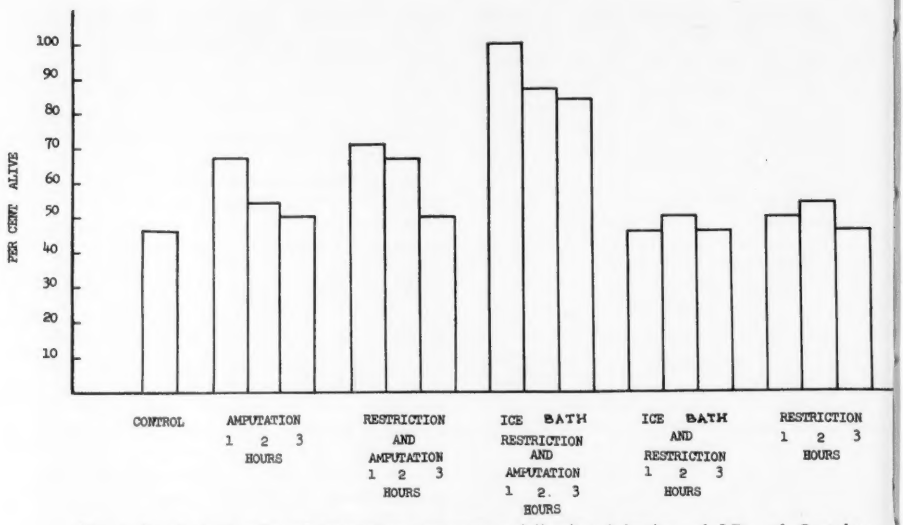

Fig. 1 Survival of mice given various treatments following injection of LD_{50} of *Crotalus adamanteus* venom.

tissues, suggesting the possibility of harmful effects from prolonged refrigeration.

Hypothermia, whether it be applied locally or to the whole animal, produces changes that can influence the effect of a drug. When tissues are exposed to chilling or freezing, the metabolic rate of those tissues is altered proportionately, and remains altered for as long a period of time as the cooling measure is maintained. When, however, the tissues are restored to their normal temperature the metabolic rate returns to normal, and absorption of the drug again takes place at its previous rate provided that no serious sequelae in the tissues or the drug have developed as a result of the cooling measure.

It is known that the freezing of living tissues causes cellular dehydration, splitting of radicals and denaturation of proteins, and that these changes usually become apparent only after the tissues have been restored to their normal environmental temperature (Baxter and Entin, 1947). Reduction in tissue temperature may cause impairment of the blood supply which in turn may lead to agglutinative erythrocytic thrombosis (Friedman, Lange and Weiner, 1947) or other serious vascular changes (Baxter and Entin, 1948).

When an extremity is placed in ice water, the temperature of the surface of the skin falls rapidly to about ice-water temperature; the deeper parts of the skin cool almost as rapidly and as much. This cooling deprives the part of its heat with result that the member becomes painful. If the individual can withstand the pain, and the immersion is continued, the pain may lessen within 5 to 20 minutes (Lewis, 1941) and the part may even feel warm. Lewis (1930) has observed that this feeling of warmth coincides with a period in which vasodilatation occurs in the involved part. The temperature of the finger rises as vasodilatation occurs and the digit again feels comfortable; if this rise is rapid the individual may complain of burning pain or throbbing. The vasodilatation, however, is of short duration and gives way again to vasoconstriction. This pattern repeats itself, the temperature of the immersed part rising and falling periodically, usually within a 2–8° C. range. When the finger is taken out of the ice bath, the temperature rises quickly to a level above that of the uncooled fingers, where it persists for some time.

Cooling an extremity to less that 6° C. elicits both direct and reflex changes that result in immediate vasoconstriction with an almost complete arrest of the circulation, followed by alternate periods of vasoconstriction and vasodilatation. A similar but smaller response follows immersion at 6°–12° C.; no initial arrest of the circulation or cold vasodilatation occurs at 12°–15° C. (Greenfield, Kernohan, Marshall, Shepheard

and Whelan, 1951). It can be seen that the vasodilatory mechanism plays an important role in protecting the cooled part from the injurious effects of low temperatures. Continuous vasoconstriction gives rise to severe and chronic arteriolar spasm with its deleterious consequences. The periodic periods of dilatation probably prevent the occurrence of such a spasm. However, the vasodilatation certainly permits a more rapid metabolism by the cell of any drug or venom within its functional boundaries.

In view of these considerations, one must not only consider the effects of the application of cooling measures on the ability of the cell to absorb a venom, but must also consider the effects of the cooling measure on the cellular protoplasm with the possible deleterious sequelae, and the possibility that the drug may act differently in these injured tissues, or under conditions of a diminished blood flow. The data presented in the present study indicate that the icing of an envenomated extremity does not decrease the probability of lethality from *C. adamanteus* venom. It may even increase lethality in those cases where the icing is applied to a large surface area. However, if the activity of the animal is restricted, and the injured part is placed in an ice bath, the period is extended in which amputation of the part can be carried out with subsequent survival of the animal. These conclusions are in part supported by the work of Bata and Vukobratovic who have demonstrated that survival time can be prolonged by local hypothermia combined with amputation.

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Summary

A study was made in mice of the effects on the LD_{50} of amputation and cooling measures to an envenomated part, and full body immobilization following injection of *Crotalus adamanteus* venom. Neither restricted activity, ice bath and restricted activity, amputation at 2 or 3 hours, or restricted activity with amputation at the end of 3 hours influenced mortality rate. Survival rate increased when the envenomated part was severed one hour following the injection. A mouse whose activity was restricted and whose tail was amputated following an hour in the ice bath had a 100 percent chance of survival; survival rate decreased with the passing of time so that by the end of the third post-injection hour it was 84 percent.

Literature Cited

Allen, F. M. 1938. Mechanical treatment of venomous bites and wounds. *South. Med. J. 31:1248–53.*

——— 1939. Observations on local measures in treatment of snake bite. *Am. J. Trop. Med. 19:393–404.*

——— 1949. Venomous bites and stings. *J. Am. Med. Assn. 139:616.*

Andrews, E. H. and C. B. Pollard. 1953. Report of snake bites in Florida and treatment: Venoms and antivenoms. *J. Florida Med. Assn. 40:388–97.*

Anonymous. 1947. Antivenin. Wyeth Inc., Philadelphia.

Bata, A. and S. Vukobratovic. 1958. Effet et application de l'hypothermie dans les morsures de serpents venimeux. *Bull. Soc. Path. Exotique 51:998–1008.*

Baxter, H. and M. A. Entin. 1947. Experimental and clinical studies of reduced temperatures in injury and repair in man. I. Structure and potentialities of human skin in temperature control and in defence against thermal trauma. *Plastic & Reconstructive Surg. 2: 569–83.*

——— 1948. Experimental and clinical studies of reduced temperatures in injury and repair in man. III. Direct effect of cooling and freezing on various elements of the human skin. *Plastic & Reconstructive Surg. 3:303–34.*

Bruneau, J. and P. Heinbecker. 1944. Effects of cooling on experimentally infected tissues. *Ann. Surg. 120:716–26.*

Crum, C. W. R. 1906. Treatment of the bites of copperhead snakes. *J. Am. Med. Assn. 46: 1433–34.*

Efrati, P. and L. Reif. 1953. Clinical and pathological observations on sixty-five cases of viper bite in Israel. *Am. J. Trop. Med. & Hyg. 2:1085–1108.*

Friedman, N. B., K. Lange and D. Weiner. 1947. The pathology of experimental frostbite. *Am. J. Med. Sci. 213:61–7.*

Fuhrman, F. A. 1946. The effect of body temperature on drug action. *Physiol. Rev. 26:247–74.*

Grasset, E. and A. Zoutendyk. 1931. Immunological studies in reptiles and their relation to aspects of immunity in higher animals. *South. African Inst. Med. Res. 4:377–460.*

Greenfield, A. D. M., G. A. Kernohan, R. J. Marshall, J. T. Shepherd and R. F. Whelan. 1951. Heat loss from toes and fore-feet during immersion in cold water. *J. Appl. Physiol. 4: 37–45.*

Haw, W. H. 1907. Two cases of snake-bite, with a suggestion for treatment. *Lancet 2: 1154–5.*

Ipsen, J. 1951. The effect of environmental temperature on the reaction of mice to tetanus toxin. *J. Immunol. 66:687–94.*

Jovanovic, M. and P. Katic. 1956. L'influence de l'hypothermie sur la sensibilité des souris envers la toxine tétanique. *XXth Internat. Physiol. Congress, Brussels, p. 477–8.*

Lewis, T. 1930. Observations upon the reac-

tions of the vessels of the human skin to cold. *Heart 15:177–208.*

——— 1941. Observations on some normal and injurious effects of cold upon the skin and underlying tissues. I. Reactions to cold and injury of normal skin. *Brit. Med. J. 20:795–7.*

MICHEEL, F. AND F. JUNG. 1936. Zur Kenntnis der schlangengifte. *Ztschr. f. Physiol. Chem. 239:217–30.*

ORNDOFF, B. H. 1915. Practical considerations of snake poisoning. *Med. Brief. 43:231–8.*

PARRISH, H. M. 1957. The poisonous snake bite problem in Florida. *Quart. J. Florida Acad. Sci. 20:185–204.*

RUSSELL, F. E. 1960a. Rattlesnake bites in Southern California. *Am. J. Med. Sci. 239:1–10.*

——— 1960b. Snake venom poisoning in Southern California. *Calif. Med. 93:347–50.*

SLOTTA, C. H. AND G. SZYSZKA. 1937. Estudos chimicos sobre os venenos ophidicos: I. Determinacao de sua toxicidade em camondongos. *Mem. Inst. Butantan 11:109–19.*

STAHNKE, H. L. 1953. The L-C treatment of venomous bites and stings. *Published by author: 4 pp.*

——— 1954. The L-C method of treating venomous bites and stings. *Poisonous Animal Res. Lab., Arizona State College, Tempe, Arizona: 28 p.*

STAHNKE, H. L., F. M. ALLEN, R. V. HORAN AND J. H. TENERY. 1957. The treatment of snake bite. *Am. J. Trop. Med. & Hyg. 6:323–35.*

TENERY, J. H. AND R. R. KOEFOOT. 1955. Snake Bite. A case with observations on early and late treatment. *Plastic & Reconstructive Surg. 15:483–8.*

WATT, H. F. AND C. B. POLLARD. 1954. Case of serious Florida diamondback rattlesnake (*Crotalus adamanteus*) bite. *J. Florida Med. Assn. 41:367–70.*

WIENER, S. 1956. The Australian red back spider (Latrodectus hasseltii): II. Effect of temperature on the toxicity of venom. *Med J. Australia 2:331–4.*

WILLSON, P. 1908. Snake poisoning in the United States. *Arch. Int. Med. 1:516–70.*

WOOD, J. T. 1956. A critique on the "L-C" treatment of snakebites. *South. Med. J. 49: 749–51.*

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A New Kingsnake from Mexico, with Remarks on the *Mexicana* Group of the Genus *Lampropeltis*

ROBERT G. WEBB

IN the summer of 1958, a small kingsnake belonging to the *mexicana* group of the genus *Lampropeltis* was obtained in southwestern Durango, México. About 9:45 P.M. Mr. J. Keever Greer and I found the snake pinned in a sprung mouse trap set at 7 P.M. on a steep, north-facing slope of a small, rocky canyon. These circumstances suggest crepuscular or nocturnal habits. Only one specimen is available for study, but its combination of characters seems to justify its nomenclaturial recognition.

I am indebted to the Michigan State University Development Fund for providing assistance in financing field work, to Mr. Alvie Adams, owner of Rancho Santa Barbara, to Mr. Fredrick R. Gehlbach for criticism of the manuscript, and to the following persons and institutions for permission to examine specimens in their care: Dr. Ernest E. Williams, Museum of Comparative Zoology, Harvard College (MCZ); Dr. Robert F. Inger, Chicago Natural History Museum (CNHM); Dr. W. Frank Blair, Texas Natural History Collection, University of Texas (TNHC). Measurements (except body and tail length) of the holotype were made to the nearest one-tenth millimeter with dial calipers.

Lampropeltis greeri sp. n.

Greer's Kingsnake

Holotype.—Michigan State University 190, young male (Fig. 1); obtained from Rancho Santa Barbara (Weicher Ranch), 29 miles west-southwest of Ciudad Durango, Durango, México, on July 18, 1958, *ca.* 7400 feet.

Diagnosis.—A species of kingsnake most closely resembling *Lampropeltis alterna* but differing from that species in having (1) bands uninterrupted by dorsal ground color (in *alterna*, alternating bands usually interrupted forming a scatter of black marks dorsally and laterally), (2), black-edged, red bands in anal region, and nuchal blotch having pale buff centers (in *alterna*, blotches and bands lack buff centers), (3) more than two-thirds of black bands widely split with red (in *alterna*, one-half or less of bands split with red), (4) distinct black pattern on

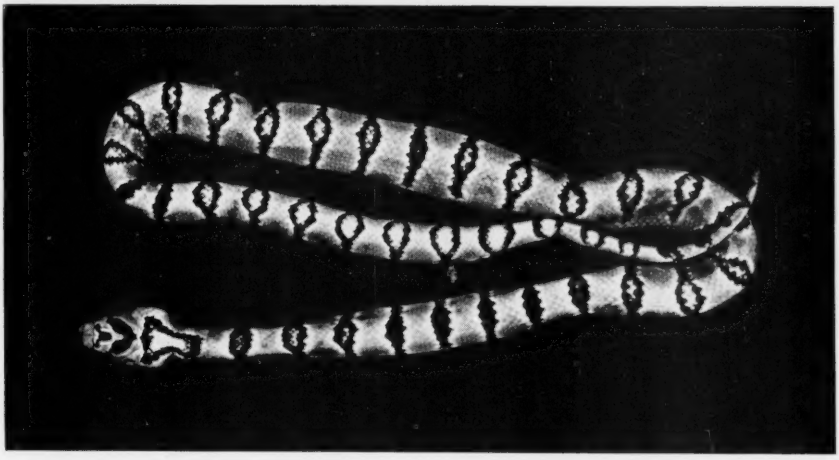

Fig. 1. *Lampropeltis greeri,* holotype (approx. × 1), dorsal view, 28.4 mi. WSW and 2 mi. S Durango, Durango, Mexico.

top of head (in *alterna,* distinct pattern on head lacking, but scattered black marks sometimes present), and (5) triangular blotch on neck (in *alterna,* triangular blotch lacking, but elongate marks sometimes present).

Description of holotype.—Male; body length 306 mm.; tail length 58 mm.; tail 15.9 percent of total length; 202 ventrals (including first widened scale); anal entire; 60 divided subcaudals, including cornified tip; dorsal scales smooth, having indistinct apical pits; dorsal scale reductions as follows (Dowling, 1951):

$$\mathbf{25}\ \frac{-12\ (24)}{-13\ (17)}\ \mathbf{23}\ \frac{+7\ (101)}{+6\ \ (91)}\ \mathbf{25}\ \frac{-6\ (107)}{-6\ \ (95)}\ \mathbf{23}\ \frac{-6\ (127)}{-6\ (126)}\ \mathbf{21}\ \frac{-5\ (148)}{-5\ (143)}\ \mathbf{19}\ (202)$$

Some scale additions and deletions not noted above are: addition of sixth row on right side opposite ventral 76 and its reduction opposite ventral 82; addition of one scale, the seventh, on left side opposite ventral 82; addition of four scales (sixth row) on right side opposite ventrals 88, 90–92; addition of four scales (seventh row) on right side opposite ventrals 112–115; addition of two scales (twelfth row) on right side opposite ventrals 137–138; and doubling of tenth row on right side opposite ventrals 157–158, 160–162.

Head (9.5 mm. wide) somewhat triangular, distinct from neck (5.3 mm. wide); snout truncate; rostral about twice as wide as high; nasal divided, nostril in anterior part; loreal wider than high; one preocular, higher than wide; two postoculars; ⅔ temporals, lower anterior temporal on right side not contacting lower postocular, and intercalary scale on left side; dorsal head scales symmetrical consisting of paired internasals, prefrontals, supraoculars and parietals, and single frontal; prefrontals contact loreal; posterior border of parietals uneven; eye large, diameter (2.5 mm.) greater than one-half length of snout (4.1 mm., measured from anterior margin of eye to tip of snout); seven supralabials, third and fourth entering orbit, sixth largest; nine (right) and ten (left) infralabials; mental triangular; first pair of infralabials in contact behind mental; two pairs of enlarged chin shields, anterior pair longest; five rows of scales between posterior pair of chin shields and first widened ventral scale.

Dorsal shields on head gray, having symmetrical black pattern in two parts; large V on parietals having widened arms that extend onto supraoculars, and small spot on frontal having two anterolateral projections onto supraoculars; small black flecks on prefrontals; lower postoculars blackish; margins of most other scales bordering eyes blackish; posterior borders of first, second and third supralabials dusky-blackish; lower margin of upper anterior temporal black on right side

of head; nuchal blotch largest on body, triangular (apex posterior, truncate), having black border and buff center (few scales red anteriorly and posteriorly).

Pattern on body of black bands or black-edged, red bands on gray background; bands narrowly edged in white (about one scale wide); 33 bands (excluding nuchal) on body, 9 on tail; no consistent sequence of black (8, some scales with red flecks) and black-edged, red bands (25); extent of red in black bands variable; black-bordered, red bands in anal region slightly larger (about four or five scales wide) than anteriorly (three scales wide), and having pale buff centers; bands widest middorsally; lateral parts of most anterior black bands (red absent) not extending below third scale row; lateral parts of most posterior black bands extending onto ventrals; red in posterior black bands extending more laterad than in anterior bands; red extending onto subcaudals and sometimes not enclosed laterally in black; bands separated dorsally by three to four scales (including narrow white borders), and laterally by five scales.

Ventral surface whitish with irregular black flecks and blotches, some blotches representing narrow lateral extensions of dorsal bands; lateral parts of some ventrals having buff-brown or gray suffusion on part of body that forms pale midventral stripe; tendency for dorsal bands to form rings under tail; underside of head whitish; margins of infralabials dusky.

Comparisons.—Lampropeltis greeri resembles *alterna,* and differs from the other members of the *mexicana* group in having a dorsal pattern on the body of narrow, black bands or black-bordered, red bands. *Lampropeltis greeri* differs from *alterna* in having none of the bands interrupted middorsally, the red of some posterior bands and the nuchal blotch split with buff centers, and most black bands widely split with red.

Lampropeltis greeri resembles *mexicana* and differs from the other members of the *mexicana* group in having distinct patterns of the same shape (smaller in *greeri*) as in some *mexicana* on the neck and top of the head. Remnants of these patterns occur in some specimens of *alterna. Lampropeltis greeri* is most closely allied to *alterna,* and a link between *alterna* and *mexicana.*

Relationships.—Lampropeltis greeri belongs to the *mexicana* group (Smith, 1942: 206; 1944:141), which is characterized by a pattern of black-bordered, red bands alternating with white-bordered, gray bands. The *mexicana* group is composed of six, little-known, monotypic species (*mexicana, thayeri, leonis, blairi, alterna,* and *greeri*).

Smith provided illustrations of the holotype of *Oreophis boulengeri* Dugès (= *Lampropeltis mexicana,* Dunn, 1922:226), and commented on the variation of the 13 known specimens (1942:202–03, 207, pl. 1, figs. 2 and 3). Smith and Necker described the holotype in detail (1943:206–08, pl. 5, fig. 3). The pattern on the head and the nuchal blotch indicate alliance of *mexicana* and *greeri.* The blotches on the nape and head are variable in configuration in *mexicana.* In the holotype of *greeri* the pattern on the head is of the same general shape as in some *mexicana* (Smith, *op. cit.:* fig. 2; MCZ 4652) but is smaller and solid black (never solid black in *mexicana*). The nuchal blotch of *greeri* resembles that of some *mexicana* (MCZ 19023), but has less red and a large central buff area.

Some specimens of *mexicana* (MCZ 19022, 24977) and *thayeri* (Smith, 1944:140; CNHM 30819–20) resemble each other in having buff areas bordered by a narrow black line inside the red blotches. Two specimens of *thayeri,* CNHM 30821 and the holotype (Fig. 2; Loveridge, 1924), have an almost ringed pattern; some black-bordered, red bands end laterally on the first and second dorsal scale rows, whereas other bands are open laterally having the black borders extending onto the ventrals. The other two known specimens of *thayeri* (CNHM 30819–20), differ from CNHM 30821 and the holotype of *thayeri,* and resemble *mexicana,* in having blotched, dorsal patterns. In 30820 the blotches are interconnected forming a dorsal, zig-zag pattern, or are broken forming dorsolateral marks. The head pattern of the four specimens consists of a large irregular red blotch (incorporating the supraoculars, frontal and anterior parts of the parietals) having an interrupted black border that is usually widest posteriorly. The nuchal blotch of the holotype of *thayeri* and of CNHM 30821 is not appreciably different from other red areas on the body, although the nuchal blotch is slightly larger; in 30819 the posterior dark border is broken and continuous with the first blotch on the body, whereas in 30820, the nuchal blotch lacks a definite pattern and dark posterior border, having only scattered, pigmented areas. The anterior black border of the nuchal blotch of the holotype of *thayeri* extends anteriorly into a point on

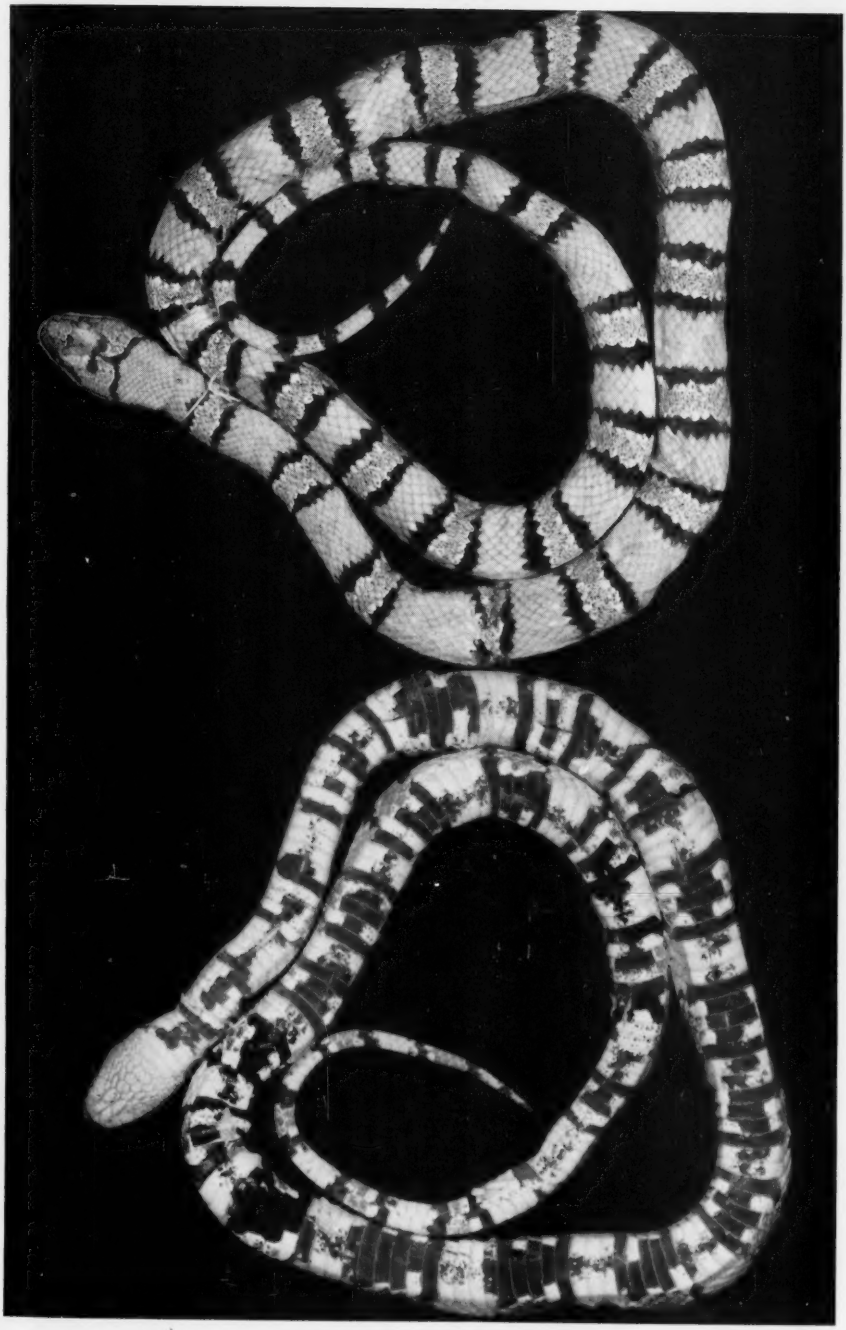

Fig. 2. *Lampropeltis thayeri*, holotype (× ⅔), Miquihuana, Tamaulipas, Mexico. Top.—Dorsal view. Bottom.—Ventral view.

the parietals and almost comes in contact with the posterior black border of the blotch on the head, thus nearly separating a wide gray area middorsally on the back of the head (Fig. 2). This feature suggests relationship with *mexicana*; some specimens of *mexicana* show a middorsal anterior extension of the nuchal blotch that may (MCZ 19022, 24976), or may not (MCZ 24978) contact the blotch on the head. Variation of the three CNHM specimens (30819–20, combining characteristics of *mexicana* and *thayeri*, and 30821, resembling holotype of *thayeri*), which are from the same locality (Ojo de Agua, near Galeana, Nuevo León), suggests conspecificity of, or perhaps hybridization between, *mexicana* and *thayeri*.

Lampropeltis leonis, known only from the holotype (Günther, 1893:110, pl. 39A), has a ∩-shaped, nuchal blotch; a pattern on the head of three black spots, each having red centers (two on parietals, one on frontal); and a blotched pattern on the body. Some *mexicana* (MCZ 19023) have head patterns resembling that of *leonis*, but they are slightly larger in *mexicana*.

Lampropeltis blairi, although resembling *thayeri*, in having an almost ringed pattern seems to be the most distinctive member of the *mexicana* group. *Lampropeltis blairi*, known from only two specimens (Flury, 1950; Axtell, 1951), has a dorsal pattern of few (13 and 14), widened, black-bordered, red blotches; the nuchal blotch is enlarged but resembles other red blotches on the body, and the holotype has distinct black marks on the head, mostly on the parietals. The species is notable in having 25 to 27 scale rows (occurring on a large anterior segment of the body) that show little reduction. *Lampropeltis blairi*, *alterna* and *greeri* differ from *thayeri* and *mexicana* (and to a lesser extent, *leonis*) in having distinctly widened heads, long tails, normally a maximum of 25 or more scale rows, and narrowly white-edged, gray bands that are wider (less so in *blairi*) than the black-edged, red bands. Also, the holotypes of *blairi* and *greeri*, and some *alterna* (TNHC 4181) have black marks on the head.

Conant (1957) provided a photograph of the holotype of *alterna* (different from that in the original description, Brown, 1902), and wrote that the seventh known specimen of the species was not reported until 1950. *Lampropeltis greeri* resembles *alterna* in having a dorsal pattern of black, or black-bordered, red bands that are narrower than the adjacent gray interspaces (less so in *greeri*, Fig. 1). The total number of dorsal bands (including the narrow, interrupted, black ones of *alterna*) is about the same in both species. All bands on the body are uninterrupted middorsally in *greeri*, whereas many black bands (usually alternating bands) are interrupted forming a scatter of small marks in *alterna*. Some posterior bands on the body and the nuchal blotch have pale buff areas inside the red in *greeri*, whereas no bands or blotches of *alterna* have the red split with pale areas. More than two-thirds of the bands (25 of 33, 76%) are widely split with red in *greeri*, whereas about one-half or less of the bands on the body in *alterna* are split with red. Mecham and Milstead (1949:140), however, reported a specimen of *alterna* having 20 of 35 (57%) black bands split with red. *Lampropeltis greeri*, having a black pattern on the head (Fig. 1), differs from *alterna*, which lacks a definite pattern, but may have an irregular pale area having scattered black marks. Wright and Wright (1957:340) wrote that one specimen of *alterna* had a U-shaped, black patch on the prefrontals; TNHC 4181 has the frontal speckled and the parietals adorned with larger black marks that are oriented to suggest remnants of a black pattern on the head. *Lampropeltis alterna* lacks the conspicuous pattern of the nuchal blotch of *greeri* (Fig. 1), but may have two elongate, lateral spots (Smith, 1942:205), or a longitudinal, bifurcated blotch (CNHM 47090, TNHC 7420). The ventral surface of *alterna* is mostly white (Mecham and Milstead, *op. cit.*), or dark gray, having a black mottling, and in indistinctly margined, midventral, whitish stripe (Jameson and Flury, 1949). The ventral surface of *greeri* is mostly whitish having a few scattered black marks; part of the undersurface is also grayish having an indistinct, midventral, whitish stripe, thus resembling some *alterna*. The only specimen of *greeri* lacks a distinct black, postocular stripe (parts of some scales are black), whereas most specimens of *alterna* have a black streak from eye to angle of mouth. The ventral count of *greeri* (202) may average lower than that of *alterna* (215–221).

Although there are too few specimens of most species of the *mexicana* group to indicate relationships properly, the kinds of characters and their occurrence in some species suggest a subspecific relationship. *Lampropeltis greeri* is intermediate between *alterna* and *mexicana*, and possible conspecificity of

thayeri and *mexicana* is mentioned in a previous paragraph.

Key to Species of the *mexicana* Group of the Genus *Lampropeltis*

1A Dorsal pattern having red areas larger than, or of about the same width as, gray areas 2
B Dorsal pattern having red areas much narrower than gray areas 4
2A Top of head dark gray or blackish, lacking distinct pattern, but sometimes having black marks; red areas on body less than 20 . . . . . *blairi*
B Top of head having distinct pattern or blotch; red areas on body more than 20 3
3A Red areas on body not extending laterally beyond fifth dorsal scale row *mexicana*
B Red areas on body extending laterally to first or second dorsal scale row *thayeri*
4A Black-bordered, red blotches on body not extending laterally beyond fifth dorsal scale row . . . . . *leonis*
B Narrow, black, crossbands on body, some of which are split or mixed with red, extending laterally beyond fifth dorsal scale row 5
5A Some black bands interrupted forming a speckling middorsally; top of head gray, lacking definite pattern, but sometimes having scattered black marks . . . . . *alterna*
B All bands complete middorsally; top of head having definite pattern of two, black, Y-shaped marks (Fig. 1) *greeri*

Speculations on phylogenetic relationships.—Prior to the discovery of *blairi* and *greeri*, Smith (1944:141–42) proposed a plausible explanation of the phylogeny of the *mexicana* group. He suggested that it was composed of two different stocks (*leonis-mexicana* and *alterna-thayeri*), and was derived from some progenitor in the *doliata* group of which *thayeri* was the most primitive species. The characters of *greeri*, which show alliance to both stocks, suggest different phylogenetic relationships.

The species of the *mexicana* group are the most primitive of all North American kingsnakes. The penial characters of *mexicana* and *alterna* tend to ally the *mexicana* group with the *doliata* group (Smith, 1942: 203–04) rather than with *L. calligaster* or *getulus*. The small hemipenes of the immature male of *greeri* do not show taxonomic characters. Three lines seem to have diverged from *mexicana*. One line is represented by *greeri* and *alterna*, and probably *blairi*. *Lampropeltis leonis* and *calligaster* show alliance to *mexicana* in having dorsal blotches on the body that do not extend far laterally, and having a blotch on neck and head. Blanchard (1921:138) placed *leonis* in the *calligaster* group. *L. calligaster* resembles a *mexicana*-like stock in usually having 1) a definite head pattern similar to that of *mexicana*, 2) a nuchal pattern of short, longitudinal stripes, sometimes connected with a dorsal blotch, which is similar to the nuchal blotch of *mexicana*, 3) a blotched pattern on the body, and 4) the brown blotches often showing a reddish tint, especially in juveniles. It may be significant also that *L. c. calligaster* normally has a well-developed, dark postocular stripe, and 25 scale rows; the maximum number in most other kingsnakes is usually less than 25. The *getulus* group is probably derived from *calligaster* but no living forms indicate relationships; *L. g. splendida* was considered to be the ancestral form of the *getulus* group by Blanchard (*ibid.*:115) and *splendida* has the southernmost extension of range into México of any subspecies of *L. getulus*.

The third stock derived from *mexicana* developed into the *doliata* group, and includes *thayeri*. The *pyromelena*-rassenkreis (Tanner, 1953) resembles some species of the *mexicana* group in having a wide head and long tail (Blanchard, *op. cit.*:6, 234). Also, the southernmost subspecies (*knoblochi*), which Tanner considered the most primitive of the four subspecies, resembles some *thayeri* in having the red areas of the dorsal pattern closed off ventrolaterally by narrow, interrupted black borders thus forming a blotched pattern, and in having an enlarged, red, nuchal blotch, and a blotch (lacking red) on the head (Taylor, 1940:253–55, figs. 1–2).

Blanchard (*op. cit.*:250) concluded that the center of dispersal of the entire genus was "... in the Southwest", a region characterized by divergence of lines of dispersal, and the occurrence of the greatest number of different kinds of kingsnakes. The forms of the *mexicana* group and the subspecies *L. doliata annulata*, *L. getulus splendida* and *L. pyromelana knoblochi*, which are considered to be primitive to their respective groups northward, all occur in southwestern Texas and/or northern México. The suggested relationships are indicated in Fig. 3.

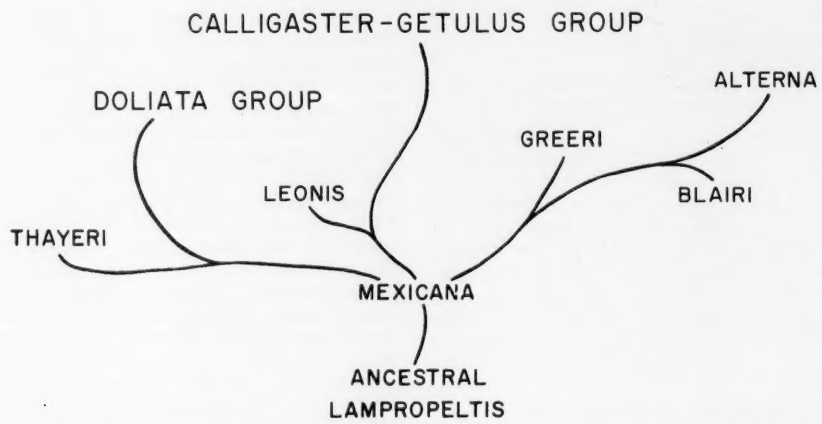

Fig. 3. Possible relationships of the species of the *mexicana* group; spatial arrangement of phyletic lines is not intended to show degree of interrelationship.

Summary

A new kingsnake, *Lampropeltis greeri*, of the *mexicana* group from southwestern Durango seems most closely related to *L. alterna*. The characters of *greeri* suggest that it is a link between *alterna* and *mexicana*. Relationships of the six species of the *mexicana* group indicate that three stocks were derived from *mexicana*: *greeri, alterna,* and probably *blairi*; *leonis* and the *calligaster-getulus* group; and *thayeri* and the *doliata* group. *Lampropeltis mexicana* is most nearly like the ancestral *Lampropeltis*. It is suggested that all other kinds of North American *Lampropeltis* are derived from the *mexicana* group.

Specimens examined (total, 18).—*Lampropeltis mexicana* (10 specimens): MCZ 4652–53 (syntypes), near San Luis Potosí, San Luis Potosí; MCZ 19022–25, 24976–79, Alvarez, San Luis Potosí. *Lampropeltis thayeri* (4 specimens): MCZ 19551 (holotype), Miquihuana, Tamaulipas; CNHM 30819–21, Ojo de Agua, near Galeana, Nuevo León. *Lampropeltis blairi* (1 specimen): TNHC 4772 (holotype), 8.8 mi. W Dryden, Terrell Co., Texas. *Lampropeltis alterna* (3 specimens): CNHM 47090, near Cuatro Ciénegas, Coahuila; TNHC 4181, 11 mi. W Valentine, Presidio Co., Texas; TNHC 7420, *ca.* 15 mi. W Bakersfield, Pecos Co., Texas.

Literature Cited

Axtell, R. W. 1951. An additional specimen of *Lampropeltis blairi* from Texas. *Copeia 1951:313.*

Blanchard, F. N. 1921. A revision of the king snakes: genus Lampropeltis. *Bull. U. S. Natl. Mus. 114:vi + 260 pp.*

Brown, A. E. 1902. A new species of Ophibolus from western Texas. *Proc. Acad. Nat. Sci. Philadelphia 53: 612–13.*

Conant, Roger. 1957. Arthur Erwin Brown "Custodian of the Garden" and naturalist of note. *America's First Zoo, Philadelphia Zool. Garden, 9:3 p.*

Dowling, H. G. 1951. A proposed method of expressing scale reductions in snakes. *Copeia 1951:131–34.*

Dunn, E. R. 1922. Note on Lampropeltis mexicana (Garman). *Proc. Biol. Soc. Washington 35:226.*

Flury, Alvin. 1950. A new king snake from trans-Pecos Texas. *Copeia 1950:215–17.*

Günther, A. C. L. G. 1885–1902. Biologia Centrali-Americana: Reptilia and Batrachia. *vi + 326 pp.*

Jameson, D. L. and A. G. Flury. 1949. The reptiles and amphibians of the Sierra Vieja Range of southwestern Texas. *Texas J. Sci. 1: 54–79.*

Loveridge, Arthur. 1924. A new snake of the genus *Lampropeltis*. *Occas. Pap. Boston Soc. Nat. Hist. 5: 137–39.*

Mecham, J. S. and W. W. Milstead. 1949. *Lampropeltis alterna* from Pecos County, Texas. *Herpetologica 5:140.*

Smith, H. M. 1942. Remarks on the Mexican king snakes of the *triangulum* group. *Proc. Rochester Acad. Sci. 8:175–207.*

———. 1944. Snakes of the Hoogstraal expeditions to northern Mexico. *Zool. Ser. Field Mus. Nat. Hist. 24:135–52.*

——— and W. L. Necker. 1943. Alfredo Duges' types of Mexican reptiles and amphibians. *An. Esc. Nac. Cienc. Biol. 3:179–233.*

Tanner, W. W. 1953. A study of taxonomy and phylogeny of *Lampropeltis pyromelana* Cope. *Great Basin Nat. 13:47–66.*

TAYLOR, E. H. 1940. A new *Lampropeltis* from western Mexico. *Copeia 1940:253–55.*

WRIGHT, A. H. AND A. A. WRIGHT. 1957. Handbook of snakes of the United States and Canada. Volume I. *Comstock Publ. Assoc., Cornell Univ. Press, xviii + 564 p.*

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Variation in Woodhouse's Toad, *Bufo woodhousei* Girard in South Dakota

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THE variation in a population of organisms is of great intrinsic interest and of importance in determining the usefulness of certain characters, qualitative and quantitative, used in taxonomic work. Unfortunately there is seldom a quantitative measure of purported variability of samples; an impression of variability is usually gained because of several extreme individuals that may be present in a population. Studies comparable to those of Kellicott (1907) and Blair (1941, 1943) are rare. Many taxonomic muddles might have been obviated had there been better understanding of intra-specific variation.

Preliminary observations made on a large population of Woodhouse's toad, *Bufo w. woodhousei,* collected in the floodplain of the Missouri River in southeastern South Dakota, indicated that the species was quite variable. The present study was undertaken to test these superficial observations.

MATERIAL AND METHODS

Measurements were made on 163 adults of Woodhouse's toad, 105 males and 58 females, collected during the years 1956 through 1959 from a sand dune area in the floodplain of the Missouri River southwest of Elk Point, South Dakota. In addition samples were obtained from two other localities, a sand bar south of Vermillion and sand bars below Gavin's Point Dam west of Yankton. The characters listed below were measured in the manner outlined by Stebbins (1954); length of body, head, snout, eyelid, parotoid gland, tibia and tarsus, parotoid width and interparotoid distance. The number of dorsal spots and the number of warts per spot were also counted, the presence and absence of a pectoral spot, whether the post-orbital crests were parallel or divergent, whether the post-orbital crests touched the parotoids, and the degree of tuberculation were also recorded. The above characters were selected because they are generally useful in the identification of various species of *Bufo.*

Body measurements were made using a divider which was then read against a ruler marked in 0.5 mm. units and an estimate made to the nearest 0.5 mm. All specimens were preserved in 65 per cent ethyl alcohol. The procedure outlined below was followed in preparing the study specimens. Shortly after their capture the toads were killed in warm tap water and then placed in 20 percent formalin for 48 hours. When the toads were taken from the water they were in a relaxed condition and could be fixed in approximately identical positions. The fore limbs were extended slightly and the hind limbs were flexed so that the toad's limbs were in what approximated a normal resting position but the body was somewhat flattened. The technique probably reduced considerably the variation that is commonly encountered with fixed material. After the specimens had been fixed in formalin they were washed in tap water for 48 hours and transferred to alcohol for permanent storage. Statistical analyses followed those outlined by Simpson, Roe and Lewontin (1960) and Snedecor (1946).

QUANTITATIVE CHARACTERS

The only character which showed evidence of sexual dimorphism was the number of dorsal spots (Table 1). Females had a significantly greater number of spots than did males ($t = 3.29$, $p < 0.002$). The range in spot number for females was 4 to 31 and for the males 3 to 35 spots. The coefficient of variation calculated was 31.9 for both sexes. Five females and 11 males had diffuse spotting and were not included in the calculation of spot number.

TABLE 1. COMPARISON OF MALE AND FEMALE *Bufo woodhousei* FROM SOUTH DAKOTA

Character	Males (105)	Females (58)
	Mean ± SE	Mean ± SE
Body Length	56.4 ± 1.2	55.4 ± 2.5
Head Length	17.5 ± 0.4	16.9 ± 0.7
Snout Length	7.2 ± 0.2	7.1 ± 0.3
Tibia Length	23.2 ± 0.6	22.4 ± 1.1
Tarsus Length	12.4 ± 0.3	12.3 ± 0.6
Parotoid Length	11.2 ± 0.2	10.8 ± 0.5
Parotoid Width	5.1 ± 0.1	4.8 ± 0.2
Inter-parotoid Distance	11.6 ± 0.2	11.4 ± 0.4
Number of Dorsal Spots	13.6 ± 0.5	16.3 ± 0.7
Warts per Spot	1.39 ± 0.02	1.41 ± 0.02
Parotoid Width × 100 / Inter-parotoid Distance	441.9 ± 5.0	434.5 ± 7.7

Although the number of spots was variable, the number of warts per spot showed little variation, the average number being nearly identical for males and females (Table 1). The coefficients of variation for males and females were 4.1 and 4.0 respectively.

The growth of body parts in adults of *B. woodhousei* was isometric. The sexes showed no significant differences in their average lengths (Table 1). There were no differences in the relative growth of body parts in the two sexes (Table 2). The correlation coefficients calculated showed no significant differences. Therefore within the size range of mature Woodhouse's toads a single equation would be satisfactory for making estimates of the size of body parts in males and females. The regression coefficients for males and females are not significantly different for any equation pair. However, the equation for the two sexes and the correlation coefficients are of sufficient interest to be presented separately.

To compare the relative variablility of the various body measurements the original measurements were converted to thousandths of the body length and the means, standard errors and coefficients of variation (V) computed (Table 3). Since the sample is probably adequate and relatively unified the V values represent inherent differences in the variability. The variability exhibited by the males and females is not markedly different, although perhaps the females are slightly more variable.

QUALITATIVE CHARACTERS

The qualitative characters studied showed some variation between three stations, Elk Point, Vermillion and Gavin's Point (Table 4). There are significant differences in the frequency of individuals with pectoral spots in the three samples. No individuals with pectoral spots were collected at Gavin's Point, approximately half the specimens from Vermillion possessed a spot, whereas only 30 percent of the toads from Elk Point had the spot. The differences between the samples from Gavin's Point and the other two stations are highly significant. The difference between the Vermillion and Elk Point samples is significant ($p \leqq 0.02$). The frequency of spotted individuals was not significantly different from year to year in Elk Point samples nor was there any association between pectoral spotting and sex.

There were no significant differences between the three samples in respect to tuberculation, presence or absence of postorbital crests and inter-orbital crests.

TABLE 2. COMPARISON OF EQUATIONS FOR ESTIMATING THE LENGTHS OF BODY PARTS IN MALES AND FEMALES OF *Bufo woodhousei* FORM SOUTH DAKOTA

Character	Sex	Equation	Correlation Coefficient
Body Length (X)	♀	$Y = 0.26X + 2.39$	0.989
Head Length (Y)	♂	$Y = 0.28X - 0.30$	0.992
Head Length (X)	♀	$Y = 0.39X + 0.46$	0.989
Snout Length (Y)	♂	$Y = 0.41X + 0.10$	0.988
Body Length (X)	♀	$Y = 0.43X - 1.26$	0.984
Tibia Length (Y)	♂	$Y = 0.46X - 2.51$	0.969
Tibia Length (X)	♀	$Y = 0.52X + 0.76$	0.935
Tarsus Length (Y)	♂	$Y = 0.48X + 1.31$	0.931
Parotoid Length (X)	♀	$Y = 0.32X + 1.38$	0.895
Parotoid Width (Y)	♂	$Y = 0.35X + 2.09$	0.837
Inter-parotoid Width (X)	♀	$Y = 0.34X + 0.96$	0.900
Parotoid Width (Y)	♂	$Y = 0.41X + 0.34$	0.934

TABLE 3. BODY PROPORTIONS OF MALES AND FEMALES OF *Bufo woodhousei* FROM SOUTH DAKOTA EXPRESSED AS THOUSANDTHS OF THE BODY LENGTH

Character	Males		Females	
	Mean ± SE	V*	Mean ± SE	V
Head Length	312.1 ± 1.5	5.0	308.7 ± 2.2	5.5
Inter-orbital Distance	99.3 ± 0.9	9.5	98.6 ± 1.4	10.7
Inter-parotoid Distance	207.1 ± 1.2	6.1	207.9 ± 2.0	7.1
Eyelid Length	142.4 ± 1.4	9.9	140.5 ± 2.3	12.5
Tibia Length	406.4 ± 2.1	5.2	401.5 ± 2.6	4.8
Tarsus Length	219.3 ± 2.2	10.1	221.6 ± 3.2	10.9
Snout Length	129.1 ± 0.7	5.6	128.8 ± 1.0	6.0
Parotoid Length	200.0 ± 1.5	7.5	197.2 ± 1.5	5.9
Parotoid Width	91.1 ± 1.0	11.4	90.2 ± 1.8	14.7

* Coefficient of Variation.

DISCUSSION

With the exception of two characters, spot number and pectoral spotting, the characters studied would be useful in comparisons of adult *B. woodhousei* with the adults of other species of *Bufo*. The extremely high correlation coefficients (Table 2) indicate that in this population only a single measurement need have been made to arrive at a reasonable estimate of the length of another body part. The correlation coefficients reported are considerably higher than those published by Kellicott (1907) for the American toad.

When the body proportions were expressed as thousandths of the body length (Table 3) the averages for the sexes for each measurement were almost identical and with the exception of parotoid width and eyelid length show rather low variability. The parotoid width expressed as thousandths of the inter-parotoid distance (table 1) was also quite variable, the *V* values for males and females being 11.6 and 12.8 respectively. Even though parotoid width was quite variable it is useful in the identification of Woodhouse's toad since other species, e.g. *B. americanus* and *B. hemiophrys*, have much wider parotoids, equal to or greater than the inter-parotoid distance.

It should be stressed that the variation reported applies only to mature toads. Immature toads showed a curvilinear growth pattern and it was extremely difficult to measure these smaller individuals; for example, the parotoid glands were not discernible until the toads had attained a body length of 20 mm., the tympanum was indistinct, and the spots were lost in the dark background of the skin.

TABLE 4. FREQUENCY DISTRIBUTIONS OF QUALITATIVE CHARACTERS IN *Bufo woodhousei* FROM SOUTH DAKOTA

Character	Elk Point	Vermillion	Gavins's Point
Divergent	95	35	4
Inter-orbital Crests			
Parallel	30	13	9
Present	136	41	12
Tuberculate			
Absent	2	0	1
Present	109	45	13
Post-orbital Crests			
Absent	2	0	1
Present	89	19	0
Pectoral Spot			
Absent	37	20	13

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SUMMARY

The variation exhibited by 163 adults of *Bufo woodhousei* from populations in southeastern South Dakota was studied. There was no evidence of sexual dimorphism in the body proportions measured, but the females had a significantly greater number of dorsal spots than the males.

The frequency of individuals with pectoral

spots differed significantly in three neighboring populations.

Literature Cited

Blair, A. P. 1941. Variation, isolating mechanisms, and hybridization in certain toads. *Genetics 26:398–417.*

———. 1943. Geographical variation of ventral markings in toads. *Am. Midland. Nat. 29:615–20.*

Kellicott, W. E. 1907. Correlation and variation in internal and external characters in the common toad (*Bufo lentiginosus americanus*, Le C.). *J. Exp. Zool. 4:575–614.*

Simpson, G. G., A. Roe, and R. C. Lewontin. 1960. *Quantitative Zoology. Rev. Ed. Harcourt, Brace and Co., New York, 440 p.*

Snedecor, G. W. 1946. Statistical methods. *College Press. Ames, Iowa, 485 p.*

Stebbins, R. C. 1954. Amphibians and reptiles of western North America. *McGraw-Hill, New York, 528 p.*

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Serum Proteins in Allopatric and Sympatric Populations of *Leptodactylus ocellatus* and *L. chaquensi*

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THE interrelation of two very similar neotropical frogs. *Leptodactylus ocellatus* and *L. chaquensis* was discussed in previous papers (Cei, 1950, 1957). *Leptodactylus ocellatus* is a widespread leptodactylid that ranges from Venezuela to south of Bahia Blanca in Argentina. *Leptodactylus chaquensis* is a related species that appears to replace *ocellatus* ecologically in the Gran Chaco (Fig. 1). The two forms are sympatric only in a relatively narrow area along the Rio Paraguay and Rio Paraná, in Paraguay and in the Argentine provinces of Corrientes and Formosa (see Fig. 1). Morphologically few characters serve to distinguish the two species, but the physiology and sexual cycle of the two species are strikingly distinct (Cei, 1948, 1949). The males of *L. chaquensis* are characterized by a discontinuous cycle of spermatogenesis in contrast to *ocellatus* which shows continuous spermatogenesis. The isolating mechanisms that function in the area of sympatry are unknown (Cei, 1956). However, statistically significant differences in the seroproteins of *ocellatus* and *chaquensis* have been demonstrated by electrophoretic methods (Cei and Bertini, 1959). At that time allopatric Argentine populations were compared: *ocellatus* from Cordoba and *chaquensis* from Tucumán. The serum protein patterns were similar in both species, but a significant difference in the ratio of two globulin fractions was obtained. The present paper is a more extensive discussion of the serum protein patterns of both species in sympatric as well as allopatric populations.

Methods and Materials

Current methods of paper electrophoresis were utilized (Wunderly, 1954; Block, Durrum, Zweig, 1955) with the following specific conditions: Whatman 3 MM paper was used and run for six hours; ionic strength 0.06; pH 8.6; buffer Veronal-Sodium Veronal; 1.5 milliamperes/centimeter. The blood was obtained by cardiac puncture, clotted, refrigerated and the sera of individual samples was usually utilized within a week. All hemolyzed samples were discarded. Samples of both species were employed in the same electrophoretic operation in order to compare the relative characteristics in the same run and electrophoretic field. The strips were treated with bromphenol blue and analyzed photocolorimetrically by elution. Samples and localities are tabulated in Table 1.

Results and Discussion

The results, tabulated in Table 1, give the relative protein concentrations of the sera. In Fig. 2 the characteristic electrophoretic patterns of *ocellatus* and *chaquensis* are illustrated.

Four evident fractions are observed in the patterns. The fastest moving fraction (A) appears to correspond to the albumin-like protein. The other three fractions, probably globulins, are indicated as G_1, G_2, and G_3. The protein fraction G_3 exhibits cathodic mobility, particularly in *ocellatus* samples. The relative concentrations of the serum proteins are shown in Table 1 and demonstrate some of the differences between the

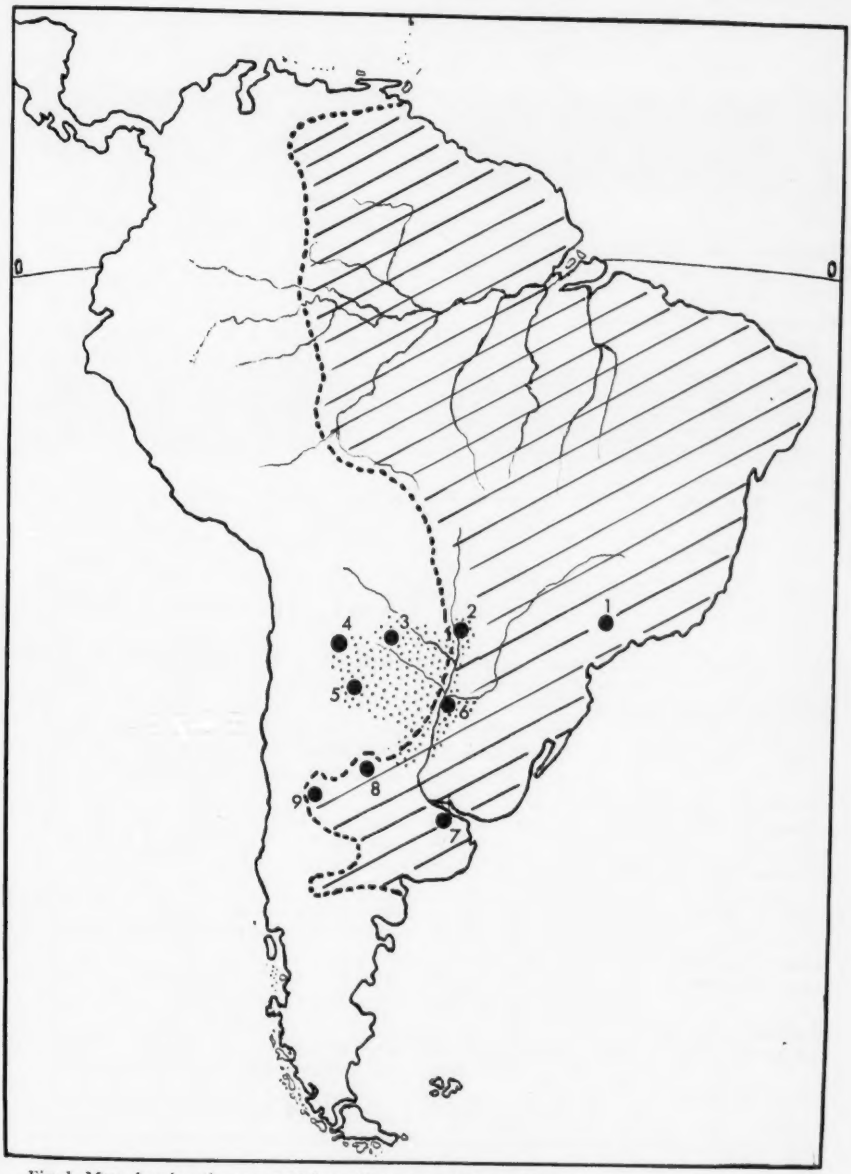

Fig. 1. Map showing the range of *L. ocellatus* (hatched area) and *L. chaquensis* (stippled). The localities are: 1. Sao Paulo; 2. Alto Paraguay; 3. Formosa; 4. Jujuy; 5. Tucumán; 6. Corrientes; 7. Buenos Aires; 8. Cordoba; 9. Mendoza.

TABLE 1. RELATIVE CONCENTRATION OF SERUM PROTEIN FRACTIONS OF THE TWO SPECIES OF *Leptodactylus* FROM VARIOUS LOCALITIES

Locality	Fractions				
	A	G1	G2	G3	G1/G2
Leptodactylus ocellatus					
Brazil (Sao Paulo)					
Nov. '59 (5 ♂)	15.0 ± 1.3* (10.8–18.0)	29.4 ± 1.0 (25.2–35.7)	27.1 ± 0.0 (26.9–27.2)	28.3 ± 2.0 (22.0–34.3)	*1.08*
Paraguay (Alto Paraguay: Primavera)					
Nov. '59 (1 ♂)	17.6	19.4	31.7	31.3	*0.61*
Corrientes (near to the town)					
Aug.–Sept. '60 (2 ♂, 3 ♀)	16.5 ± 1.4 (11.3–20.1)	23.1 ± 2.7 (18.5–33.5)	23.6 ± 1.6 (20.0–27.8)	36.9 ± 3.8 (24.3–45.7)	*0.97*
Buenos Aires (La Plata)					
Aug. 60 (8 ♂, 4 ♀)	14.8 ± 0.7 (10.3–18.5)	20.9 ± 0.8 (16.9–26.1)	23.8 ± 0.6 (20.2–26.2)	40.4 ± 1.2 (34.7–47.1)	*0.87*
Oct. '60 (1 ♂, 1 ♀)	14.7	19.1	23.3	42.9	*0.82*
Cordoba (Sierras)					
Aug. '59 (10 ♂)	16.2 ± 0.6 (12.2–19.3)	33.2 ± 1.1 (24.6–35.7)	21.1 ± 0.6 (18.1–23.8)	30.5 ± 1.8 (25.3–42.6)	*1.52*
Aug. '60 (4 ♂)	12.8 ± 1.5 (8.7–15.8)	20.8 ± 2.9 (23.1–36.7)	19.7 ± 0.6 (18.4–21.3)	37.7 ± 3.3 (31.5–46.9)	*1.51*
Mendoza (near the town)					
Aug. '60 (1 ♂)	15.1	28.1	20.7	31.1	*1.35*
Leptodactylus chaquensis					
Paraguay (Alto Paraguay: Primavera)					
Nov. '59 (4 ♂)	21.2 ± 3.5 (13.8–29.0)	30.6 ± 2.2 (26.8–33.8)	23.0 ± 0.9 (21.7–25.6)	25.1 ± 3.3 (18.3–33.5)	*1.33*
Corrientes (near the town)					
Aug.–Sept. '60 (16 ♂, 7 ♀)	17.1 ± 0.8 (9.7–24.3)	28.6 ± 0.8 (20.5–35.4)	19.0 ± 0.4 (14.9–23.3)	35.3 ± 1.3 (24.3–51.0)	*1.50*
Formosa (Central Chaco) Ing. Jaurez)					
March '60 (7 ♂)	23.8 ± 1.1 (21.1–29.6)	32.3 ± 1.2 (25.9–35.5)	18.9 ± 0.6 (16.8–21.2)	24.9 ± 1.0 (22.4–30.4)	*1.70*
Jujuy (near the town)					
March '60 (4 ♂)	14.1 ± 2.2 (10.0–19.1)	38.5 ± 3.7 (30.3–48.1)	19.0 ± 0.9 (16.7–21.4)	28.4 ± 3.3 (22.6–36.5)	*2.02*
Tucuman (San Miguel)					
Aug. '59 (6 ♂, 1 ♀)	18.2 ± 0.79 (16.4–21.4)	37.3 ± 0.4 (36.4–39.5)	15.7 ± 0.4 (14.2–17.2)	28.5 ± 0.7 (25.4–30.2)	*2.37*
Nov. '60 (3 ♂)	19.9 (17.3–24.1)	28.3 (27.4–29.3)	19.2 (17.3–21.0)	32.5 (29.2–35.8)	*1.47*

*Mean ± S.E.

two species. No sex difference was found in either species.

The fraction A is usually relatively more concentrated in *chaquensis* than in *ocellatus*. The averages of this protein for the various geographic samples range from 14.1 percent to 23.8 percent in *chaquensis* (with an individual range of 9.7 percent to 29.6 percent) while in *ocellatus* the samples range from 12.8 percent to 17.6 percent (the individual

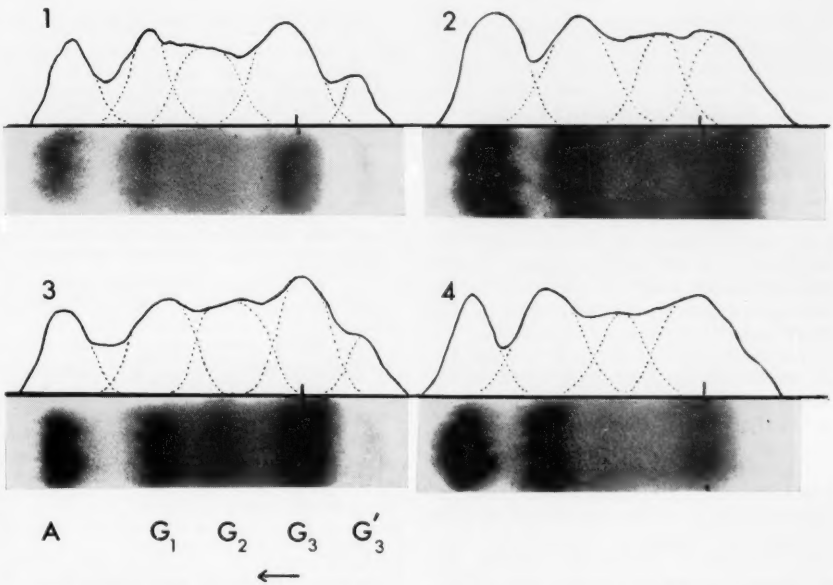

Fig. 2. Electrophoretic patterns of two sympatric and allopatric populations of *L. ocellatus* and *L. chaquensis*: 1. *ocellatus* from Corrientes; 2. *chaquensis* from Corrientes; 3. *ocellatus* from La Plata; 4. *chaquensis* from Tucumán.

values range from 8.7 percent to 20.1 percent).

The G_3 fraction in *ocellatus* very often demonstrates evidence of a fourth globulin fraction (G_3'). The values of G_3 in Table 1 include the G_3' fraction. No such fraction is usually evident in *chaquensis*. The G_3' fraction is easily detectable by elution in *ocellatus*, but not in *chaquensis*.

The ratio G_1/G_2 is a measure of the relative concentrations of these bands of lower mobility. This ratio, like fraction A, illustrates the considerable geographic variation that exists in both species. In *chaquensis* the population averages range from 1.33–2.37, while in *ocellatus* they range from .61–1.52. There is, therefore, overlap of the index values between the two species. However, it is of interest to note that sympatric populations of the two species are sharply distinguishable by their G_1/G_2 value: in Corrientes, *ocellatus* 0.97, while *chaquensis* 1.50; in Alto Paraguay, *ocellatus* 0.61, while *chaquensis* 1.33. Similar ratios have been obtained only between allopatric populations of both species.

There is also evidence of seasonal variation in the G_1/G_2 ratio for *chaquensis* in Tucumán. The sharp difference between the August and November values is probably attributable to the pronounced seasonal sexual activity characteristic of *chaquensis* (Cei, 1948, 1949). The sexual endocrine activity may cause variations in the lipoprotein level in the blood, which would affect the relative concentrations of the fractions. In *ocellatus* samples from Cordoba in two different years (August 1959 and 1960) show sharp constancy in the G_1/G_2 ratio. Similarly, samples from Buenos Aires taken two months apart gave equivalent ratios. As a consequence of the continuous sexual cycle of *ocellatus* there is apparently less seasonal variation in the serum protein concentrations than in *chaquensis*.

The characteristic seroprotein patterns of the two species in the sympatric zone supports the interpretation that *chaquensis* and *ocellatus* are two separate species. This case is similar to the discussion of the status of the turtles *Pseudemys floridana floridana* and *P. f. suwaniensis* by Zweig and Crenshaw (1957). These forms exhibit an analogous variation in the protein concentrations in two fractions of their electrophoretic patterns and also demonstrate reproductive isolation in the microgeographic zone of sympatry (Crenshaw, 1955). The results obtained

in comparing two closely related species such *chaquensis* and *ocellatus* confirm Zweig and Crenshaw's contention that paper electrophoresis is a useful tool in determining infrageneric relationships.

Summary

Leptodactylus ocellatus and *L. chaquensis*, two closely related species of Argentine anurans, were compared by an electrophoretic study of the serum protein patterns. Significant differences were obtained between the two species, both in the comparison of allopatric as well as sympatric populations.

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Literature Cited

Block, R. J., Durrum, E. L. and Zweig, G. 1955. Manual of Paper Chromatography and Paper Electrophoresis. *Academic Press Inc., New York.*

Cei, J. M. 1948. El ritmo estacional en los fenomenos ciclicos endocrinosexuales de la Rana Criolla (*Leptodactylus ocellatus* L.) del Norte Argentino. *Acta Zool. Lilloana 6:283–331.*

———. 1949. Factores geneticos raciales que diferencian la regulación hormonal del ciclo sexual en *Leptodactylus ocellatus* de la Argentina. *Ibid. 7:113–134.*

———. 1950. *Leptodactylus chaquensis* n. sp. y el valor sistemático real de la especie linneana *Leptodactylus ocellatus* en la Argentina. *Ibid. 9:395–423.*

———. 1956. Observaciones genéticas preliminares en poblaciones de Anfibios argentinos. *Biológica, Santiago de Chile 22:45–49.*

———. 1954–57. Notes batracologicas y biogeograficas argentinas. III. *An. Depto. Invest. Cient., Univ. Nac. Cuyo, Mendoza 2(2):5–9.*

——— and F. Bertini. 1959. Diferencias entre *Leptodacylus ocellatus* y *L. chaquensis* reveladas por via electroforetica en suero. *Acta 1° Congr. Sudamer. Zool. Nov. 1959, La Plata. (in press).*

Crenshaw, J. W. 1955. *Ph. D. Disertation, Univ. of Florida.*

Wunderly, Ch. 1954. Die Papierelectrophorese. *Sauerlander & Co., Aarau.*

Zweig, G. and J. M. Crenshaw. 1957. Differentiation of species by paper electrophoresis of serum proteins of *Pseudemys* turtles. *Science 126:1065–1067.*

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Embryonic and Larval Development of *Hyla avivoca*[1]

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Approximately 25 years after Viosca (1923, 1928) had designated an adult tree frog with a distinctive bird-like call as *Hyla avivoca*, a tadpole with a unique pigmentary pattern, but of uncertain parentage, was described by Parker (1951) as representing this species. Parker's tenuous diagnosis of the tadpole was verified by Hellman (1953). The latter obtained embryos from known parents, and reared the larvae through metamorphosis, to insure positive identification.

Presented herein is a copious treatment of the early development of *Hyla avivoca* from a population in eastern Louisiana, close to the locality in which Viosca had discovered the species. Throughout our presentation, constant reference is made to the two previous descriptions so that the characteristics of the egg, embryos, and larvae of the bird-voiced tree frog from Louisiana may be contrasted with those from Tennessee (Parker, *op. cit.*) and Florida (Hellman, *op. cit.*).

[1] Mittleman (1945) proposed to resurrect Cope's *Hyla phaeocrypta* as the valid name for the bird-voiced tree frog. However, this claim for a nomenclatural change remains dubious (see Smith, 1953).

Materials and Methods

The study was initiated by the capture of nine males and three gravid females, two in amplexus, on May 18, 1960 in a gum-cypress swamp located 0.2 mile north of the junction

of U.S. Highway 11 and La. Highway 41 at Pearl River, in St. Tammany Parish, Louisiana. The individuals were found in the thickly-wooded areas of the swamp; pine trees were dispersed among the cypress, buttonbush, and tupelo vegetation. The depth of the water in most spots was approximately four feet. The only calls heard, other than the plaintive whistles of *H. avivoca*, were those of *Rana clamitans* and *R. catesbeiana*.

The unmated female was located close to the water surface (on a log), but the two mating pairs were found on upright branches three to four feet above the water surface. It is not known whether the clasped females, if undisturbed, would have descended into the water to deposit their eggs. Lest these long-sought females escape, they were seized soon after being detected, and brought to the laboratory.

Two females yielded eggs in the laboratory, each by a different method. Eggs were deposited by one clasped female in a gravel-bottomed terrarium containing pond water at a depth of one inch, whereas eggs from the second female were inseminated artificially (Rugh, 1934). The embryos derived from the natural cross were so similar to those obtained from the artificial cross that both groups will be treated as one in the presentation of the data.

A complete developmental series was obtained by rearing the embryos through metamorphosis. Measurements of the embryos and gelatinous envelopes were made to the nearest 0.01 mm. with a Filar micrometer eyepiece inserted into a stereoscopic microscope. The embryos were under continual surveillance, particularly during the hatching period, when almost uninterrupted observations were made (by one or two of us at a time). The larvae were reared at room temperatures (28.5–31.5° C.) in pond water on a diet of boiled spinach. At regular intervals, several larvae were preserved in 10 percent formalin and studied. Photographs were also taken of living larvae (narcotized in "M.S. 222") to reveal the distribution of formalin-soluble pigments in certain chromatophores. These procedures enabled us to reconstruct the changes in the embryo and its gelatinous envelopes, the process of hatching, the differentiation of the mouthparts, and the pigmentary patterns at various stages of development. It is a pleasure to acknowledge our indebtedness to Mrs. Carolyn Thorne Volpe for the skillful preparation of the figures. This investigation represents an outgrowth of researches on anurans supported by a grant from the National Science Foundation (NSF-G16317).

The Egg and Its Gelatinous Envelopes

Each egg is dark brown at the animal hemisphere, shading to a white or cream at the vegetal pole. The mean diameter of the vitellus at the two-cell stage was 1.17 mm. (range of 25 eggs: 1.10–1.21). These values are at variance with those of both Parker (*op. cit.*) and Hellman (*op. cit.*). The diameters of eggs measured by Hellman ranged from 1.3 to 1.4 mm. (mean: 1.38); those recorded by Parker varied from 0.8 to 0.9 mm. The eggs measured by Hellman were in the two- and four-celled stages, equivalent to the period of development in which we had taken our measurements. There may be considerable geographical variation in egg size.

The number of gelatinous layers surrounding the vitellus is subject to interpretation. The first or inner layer, closely adherent to the vitelline membrane, is firm and transparent. The second envelope is softer in consistency and relatively transparent, and is enclosed by a loose jelly film. Both Parker and Hellman reported only two envelopes; presumably they considered the jelly film as representing merely the sticky, outer surface of the second envelope. However, it should be noted (Fig. 1) that the jelly film is clearly delimited from the second envelope and averages 0.22 mm. in thickness shortly after fertilization (two-cell stage). One could justifiably assert that this relatively thick jelly film constitutes a third gelatinous coat.

The pliable jelly film is responsible for the adhesion of the eggs to a solid surface, e.g., gravel or vegetation. All eggs in our culture were submerged below the water surface, in loose clumps, attached to the gravel. There was no tendency for the eggs to float. The surface masses observed by Parker were probably attached to objects (twigs, sticks, and aquatic vegetation) at the water level. As shown in Figure 1, the jelly film becomes progressively thinner during development. The thinning of the film is not attributable, as one might imagine, to a liquefaction or dissolution of the jelly. Our observations indicate that the jelly film is stretched thin by the continual enlargement of the second envelope.

The diameters of the second envelope (presumably including the jelly film) recorded by Parker and Hellman agree very closely, ranging from 4.0 to 5.4 mm. The average

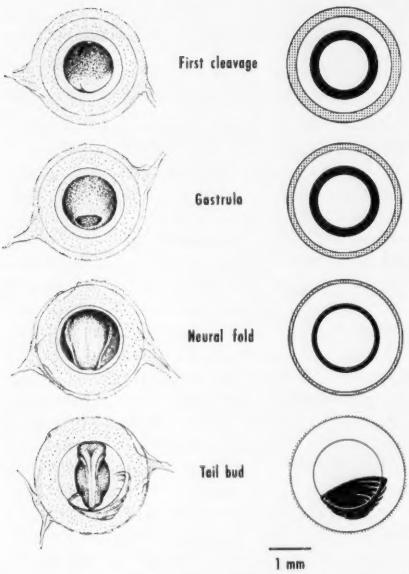

Fig. 1. *Left*, actual appearance of embryos and envelopes of *Hyla avivoca*. *Right*, schematic representation illustrating fate of gelatinous coats during development, particularly the first envelope (solid black) and the outer jelly film (stippled).

diameter of the second envelope in our sample of 25 eggs measured at the two-cell stage was 2.73 mm. (range: 2.46–2.93). The second envelope imbibes water during the course of development, and it was thought at first that the size discrepancy might reflect differences in the developmental stages at which the embryos were measured. However, at no period between stages 3 (first cleavage) and 17 (tail bud formation) did the second envelope reach a size as large as 4.0 mm. Perhaps the media used by Parker and Hellman promoted greater absorption of water by the second envelope than the solution (unanalyzed pond water) employed by us.

The fate of the first or inner envelope is depicted in Figure 1. Whereas the second envelope imbibes water, the first does not. Indeed, the first envelope apparently loses water as development progresses. The average diameters (based on 25 eggs) of the first envelope at stages 3 (first cleavage) and 10 (gastrula) are virtually identical, 1.60 and 1.61 mm., respectively. Although the diameter of the first envelope has remained the same, the average diameter of the vitellus has increased from 1.17 mm. (range: 1.10–1.21) at the two-cell stage to 1.26 mm. (range: 1.24–1.29) at the gastrula stage. This represents a decrease in thickness of the first envelope from 0.22 to 0.18 mm. It is suggested that the first envelope serves as a transfusion area, regulating the passage of water into the vitelline capsule and actually contributing water to the vitelline fluid.

A comparable situation is witnessed in later development (Fig. 1). The increase in size of the embryo (and its associated vitelline capsule) is not accompanied by a concomitant increase in the diameter of the first envelope. Obviously, a point must be reached where the first envelope becomes so taut that it breaks. This is exactly what was observed. At stage 17, the remnant of the first envelope was seen as a cap-like mass attached to one side of the vitelline membrane.

The Process of Hatching

The antero-posterior elongation of the embryo during neurulation is accompanied by an increase in the diameter of the vitelline membrane. During the closure of the neural tube (stage 15), the embryo begins to rotate slowly by means of ciliary action. Ciliary activity is inferred from the movement of particles in the vitelline fluid surrounding the embryo. Subsequent developmental changes are illustrated in Figure 2.

During tail bud formation, the embryo elongates to such an extent that the tail is curved within the contours of the vitelline membrane (Fig. 2A). The cap-like remnant of the inner gelatinous envelope may be seen adhering to one side of the vitelline membrane. At stage 18, spontaneous muscular movements occur, consisting initially of slow, unilateral flexures of the head. As development progresses, the muscular spasms occur more frequently and with greater intensity. The head and tail are often flexed simultaneously, resulting in a U-shaped embryo at the height of muscular effort. Prior to hatching, a typical sequence of events comprises (1) the rotation of the embryo within the vitelline capsule, (2) an interruption of the circling movements by a rapid muscular contraction, (3) a brief period in which the embryo remains at rest, and (4) the renewal of rotational activity.

At stage 20 (Fig. 2B), the vitelline membrane appears thin and loses its tautness. The head is pressed firmly against the vitelline membrane throughout its rotational movements. The softening of the vitelline

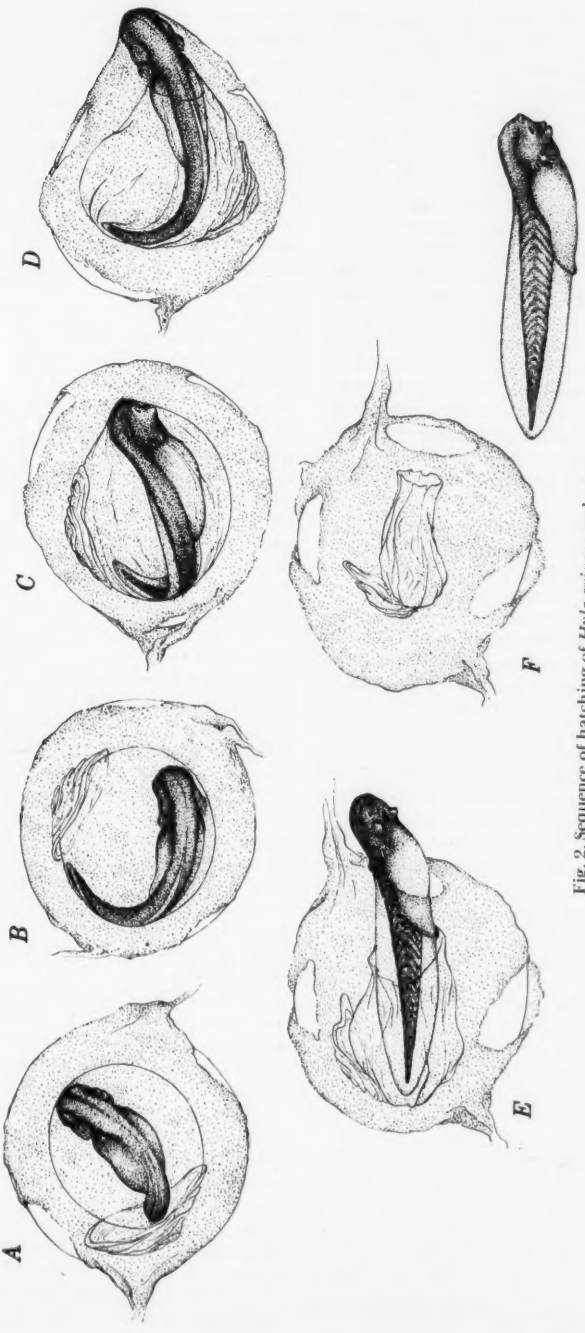

Fig. 2. Sequence of hatching of *Hyla avivoca* embryos.

membrane may be due to secretions of the "frontal gland" (Noble, 1926) in the cephalic integument of the embryo. Hatching is initiated when the head causes a bulge in the vitelline membrane (Fig. 2C). The membrane then breaks at the point where it is stretched tightly over the surface of the head. The emergence of the embryo is not abrupt or explosive, indicating that little or no pressure is exerted by the vitelline fluid. Indeed, as shown in Figure 2D, the vitelline membrane, although not as taut as in earlier stages, does not collapse when the head penetrates through the opening.

When the head has emerged, the remainder of the embryo follows slowly and gradually (Fig. 2E). Slight twitching of the head may accompany emergence, but no strong muscular contractions are involved. The gradual, gliding motion of the emergent embryo suggests that the embryo is propelled primarily by ciliary action.

A graceful emergence of the embryo is not invariable. We have also noted that a strong, threshing movement of the embryo can cause the vitelline membrane to rupture (as if prematurely), in which event, the vitelline membrane immediately wrinkles and collapses about the embryo. The embryo subsequently frees itself from the jelly mass by additional muscular movements.

The embryo is capable of swimming for short distances immediately after hatching. The embryo at hatching (Fig. 2F) is light cream to dull brown in color. The external gills are distinct and branched, the nasal pit is deep, and the lens vesicle is faintly visible through the cornea. In the castoff gelatinous mass may be seen the cap-like remains of the inner jelly envelope and the shrivelled vitelline membrane. The edges in the aperture of the vitelline membrane appear lacerated. Apparently the initial small opening in the vitelline membrane is enlarged mechanically by tearing as the embryo emerges.

TABLE 1. THE EMBRYONIC DEVELOPMENT OF LOUISIANA *Hyla avivoca* UNDER LABORATORY CONDITIONS (28.5–31.5°C.)

Age in Hours	Stage[1]	Age in Hours	Stage
0	1	16.5	14
1	3	18.7	16
1.5	4	20.5	17
2.0	5	25.0	18
2.7	6	30.5	19
3.5	7	34.7	20
4.2	8	43.0	21
6.5	9	53.5	22
8.0	10	65.7	23
10.0	12	81.5	24
13.5	13	113.0	25

[1] The stages of development are described and illustrated in Limbaugh and Volpe, 1957.

STAGES OF DEVELOPMENT

The development of *Hyla avivoca* has been designated according to a series of stages in the normal development of *Bufo valliceps* (Limbaugh and Volpe, 1957). The features of the stages are essentially similar to those given by Shumway (1940) and Taylor and Kollros (1946) for *Rana pipiens*. These developmental series on bufonids and ranids are easily adapted for staging the hylid embryos and larvae. Recently Gosner (1960) presented a simplified and generalized system for staging anuran developmental series. The adoption of this system for general use is recommended, as comparative studies of different species must be based on equivalent developmental stages.

Data on embryonic development (stages 1–25) of *Hyla avivoca* are recorded in Table 1. The age, in hours, accompanying a given stage refers to time elapsed since fertilization. Hatching was first observed at 40 hours after fertilization, when the embryos were in late stage 20, approaching stage 21. The mean length of the hatchlings (snout to tip of tail) was 4.65 mm. (range of 15 individuals: 4.32–4.94). The newly hatched *avivoca* embryos in Hellman's sample varied from 4.1 to 5.0 mm. (mean: 4.6). The period from hatching to resorption of the gills (stage 25) was relatively long, lasting approximately three days. During this interval, the embryos grew rapidly; the total length of ten embryos measured at stage 25 averaged 7.4 mm. (range: 7.15–7.86).

No attempt was made to ascertain precisely the extent of variation in growth rates of the tadpoles. The majority of the tadpoles entered stage 30 (the hind limb is a small, undifferentiated bud) at five days after the onset of larval development (stage 26). Seven days elapsed between stages 30 and 35, when five interdigital indentations are present on the distal part of the hind limb bud. The majority of the tadpoles entered stage 40, when the foot of the hind limb is differentiated, eight days after stage 35. The period of metamorphosis, comprising stages 42–46, extended over four days. Thus, the larval period of *avivoca* under laboratory conditions encom-

passed 24 days, and the total developmental period (from fertilization to transformation) was approximately 29 days. The body lengths (snout to vent) of ten specimens preserved at transformation averaged 10.1 mm. (range: 9.4–11.4). Transformation sizes recorded by Hellman for *avivoca* from Florida are between 12.1 and 13.2 mm.

The linear dimensions of the tadpoles at each stage of larval development are represented in Figure 3. Total length (snout to tip of tail) is plotted against developmental stage to reveal the ranges of sizes that were achieved by the larvae under the growth conditions utilized. It is evident that body dimensions not only change continuously during development but are highly variable at a given stage of development.

In our sample, the largest size attained by an *avivoca* tadpole was 33.5 mm. at stage 40, at which stage the larvae varied in length from 27.5 to 33.5 mm. These values at stage 40 (or the values at any other stage) should not be misconstrued as constituting the potential limits of growth that may be realized by the tadpoles of this species. Further studies, utilizing a variety of environmental conditions, may reveal the potential minimum and maximum sizes at each stage of development.

The stages of larval development, pictorialized in Figure 3, deviate but little from the developmental sequence in *Rana* and *Bufo* (see Limbaugh and Volpe, *op. cit.*; Gosner, *op. cit.*). One of the features peculiar to the larval development of *Hyla* is the differentiation of the toe pads. The following descriptive material will be of supplementary assistance in identifying stages 38, 39, and 40 in hylid tadpoles:

Stage 38. The metatarsal (prehallux) tubercle appears; the distal ends of the toes are undifferentiated.

Stage 39. The distal ends of the toes exhibit slight thickenings, foreshadowing the differentiation of toe pads. The metatarsal tubercle is a pronounced outgrowth.

Concomitant with the early differentiation of the toe pads is the development of subarticular tubercles. The latter first appear in pigment-free areas on the in-

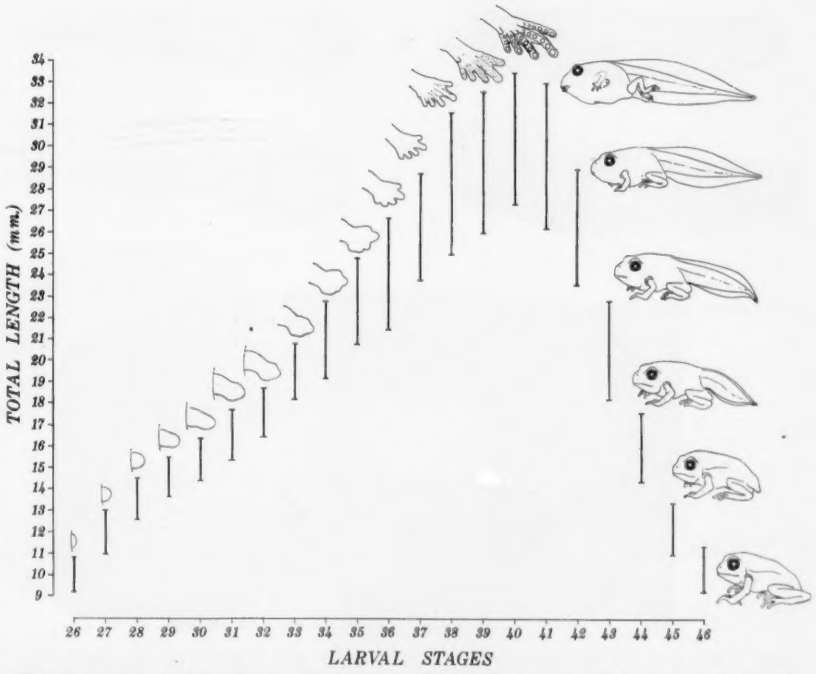

Fig. 3. Size-stage relationships in *Hyla avivoca*, and a pictorial representation of the distinguishing features of each stage of larval development.

ner surface of the toes. Some of the tubercles are slightly elevated at this stage.

Stage 40. The distal toe pads are thickened and elliptical-shaped; the subarticular tubercles are clearly elevated.

Pigmentary Pattern

Concurring with Parker's and Hellman's descriptions, the most striking pigmentary aspects of the larva are (a) a well defined light band extending from the eye to the tip of the snout, (b) a butterfly-shaped mark located between and immediately behind the eyes, and (c) a series of coppery-red "saddles" (Parker's expression) on the dorsolateral portion of the tail musculature. These features of the larva are foreshadowed in late embryonic development (Fig. 4). Prior to the resorption of the gills (stage 23), the dorsal tail musculature is conspicuously marked by a series of light areas (Fig. 4A). Each light area (or "saddle") is an immobile layer of pigment, which appears red by reflected light. Scattered, discrete yellow chromatophores are also evident. At stage 24 (Fig. 4B), the yellow chromatophores tend to aggregate in certain regions, forming notably the preorbital and interorbital markings.

During larval development, the light-reflecting red pigment seems to lose its luster and gradually fades from view. Hellman had also commented on the apparent loss of red coloration. However, the red pigment does not fade, but is merely obscured by the increasing numbers and activity of the yellow chromatophores. Figure 4C reveals the arrangement of pigment in a "saddle". Numerous yellow chromatophores mask the underlying diffuse layer of red pigment. The amount of red seen by reflected light depends upon the degree of dispersion of pigment granules within the yellow chromatophores. The red pigment is exposed when the yellow pigment is concentrated into small masses in the centers of the chromatophores. Contrarily, in the fully dispersed state, the yellow pigment is diffused over a greater surface, effectively obscuring the underlying red pigment.

There is no difficulty in identifying the larva throughout development, notwith-

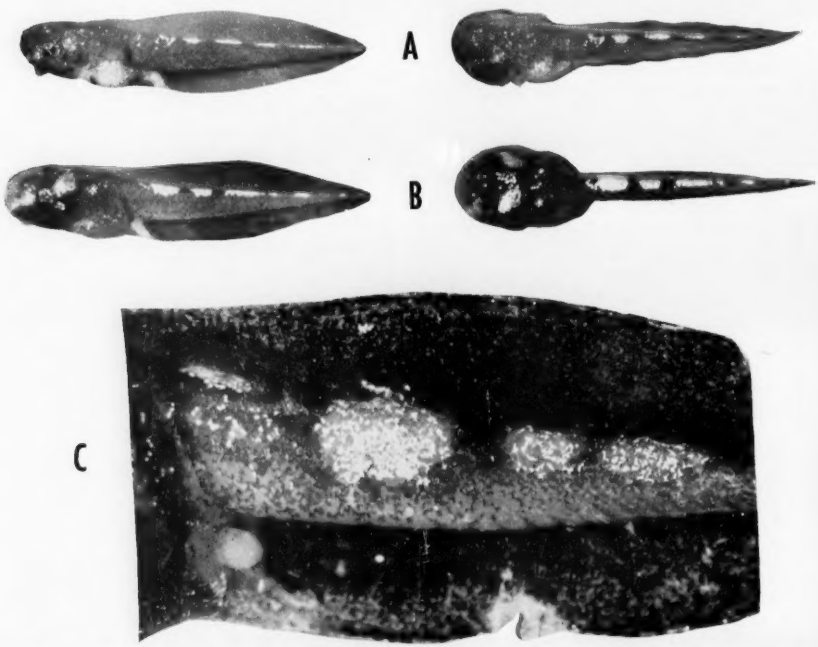

Fig. 4. Initial formation of pigmentary pattern in embryonic stages 23(A) and 24(B) of *Hyla avivoca*. Two distinct pigments comprise each light tail "saddle", as seen in the enlarged view (C) of the tail of a larva at stage 29 (see text for details).

standing changes in the pigmentary pattern. Lateral and dorsal views of larvae in three different stages of development are shown in Figure 5. The "saddles" are invariably present, but there is no characteristic number. The Tennessee tadpoles described by Parker contained 3 to 4 tail "saddles" and the Florida specimens studied by Hellman had 4 to 7 such marks. As seen in Figure 5, the "saddles" tend to become confluent; only a few remain as discrete entities. It should be noted also, that whereas the preorbital stripe persists throughout larval development, the butterfly-shaped interorbital pattern becomes obscured by the invasion of melanophores.

The tail musculature is irregularly patterned by melanophores. In early larval development, the dorsal half is darkened by melanophores and the ventral half contains scattered melanophores. Continual differentiation of melanophores results in a progressive narrowing of the unpigmented ventral fraction.

The transparent tail fins are flecked with melanophores and yellow chromatophores, the number varying with the stage of development. In general, the intensity of mottling of the fins increases progressively during development.

The red pigmentation in the saddles is highly diagnostic of living specimens, but obviously color is of no aid in identifying preserved specimens. The appearance of the tail after formalin preservation is illustrated in Figure 6. Devoid of formalin-soluble red and yellow pigments, the "saddles" appear as immaculate blocks extending half the width of the tail musculature. The formalin-preserved speciment illustrated in Figure 6 is the same larva that was photographed while alive and depicted in Figure 5A. It is

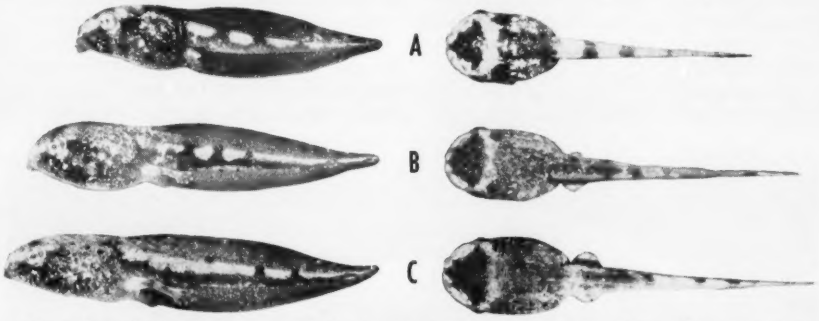

Fig. 5. Lateral and dorsal views of living larvae of *Hyla avivoca* at stage 31(A), 37(B), and 39(C).

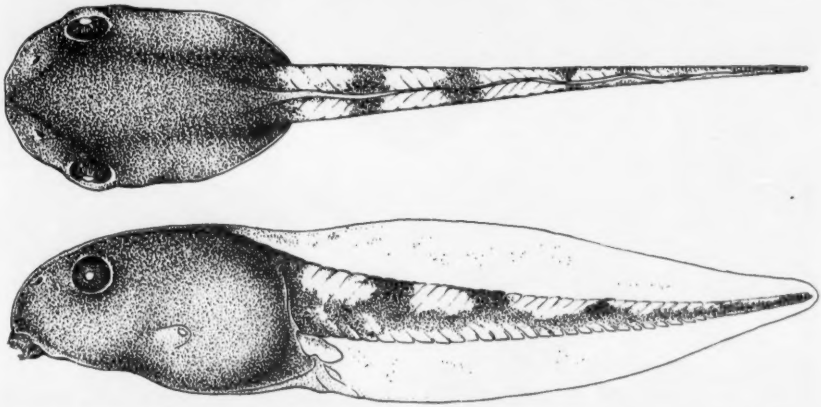

Fig. 6. Lateral and dorsal views of a formalin-preserved larva of *Hyla avivoca* at stage 31. Compare with photograph of living larva (Fig. 5A).

evident that larval descriptions based solely on preserved specimens are not only incomplete but may be misleading.

In contrast to the prominent larval pattern, the newly transformed individual lacks conspicuous pigmentary features by which the species may be identified. The adult dorsal pattern is not foreshadowed in the metamorphosed young. The transformed individual is light green dorsally, with speckled black markings on the hind limbs.

Larval Mouthparts

The mouthparts begin to differentiate during the closing stages of the embryonic period. Cornified frameworks of the mandibles and rudiments of the labial ridges are recognizable at embryonic stage 23. Teeth are evident at stage 24, arising in the first upper labial ridge and the first and second lower labial ridges. The inner edges of the horny mandibles are pigmented and serrated. At stage 25, the tooth formula is 2/2. A third lower tooth row is the last to develop, becoming evident in larvae at stage 26.

The configuration of the oral disc at larval stage 38 is shown in Figure 7. The labial tooth formula is 2/3. The first tooth row in the upper labium is continuous; the second is divided medially. The median space of the second upper tooth row is generally half the length of either lateral segment of teeth. Measurements of 65 tadpoles at stage 38 revealed that the median gap varies from 0.26 to 0.79 times the length of either lateral segment.

There are three continuous rows of teeth on the lower labium. The first and second lower tooth rows are equal in length. The third lower row corresponds in outline to the second lower row but is 0.37 to 0.69 times the length of the second.

The upper mandible is weakly arched; the lower is broadly V-shaped. Papillae encircle the oral disc except for a short space along the upper median margin. The oral disc is not emarginate, i.e., the papillary fringe is not indented at the corners of the mouth. A cluster of papillae occurs at each corner of the mouth.

Modifications of the above pattern were found. However, the individual variations were not of sufficient magnitude to obscure the basic configuration of the tooth rows. The

Fig. 7. Oral disc of larva of *Hyla avivoca* at stage 38.

principal deviation was an incomplete tooth row, i.e., a portion of a row lacked few to several teeth. The first lower row was more prone to having missing teeth than the other rows. In occasional specimens, the first lower tooth row was interrupted medially by a short space.

Summary

The long-awaited opportunity to study the early development of the bird-voiced tree frog, *Hyla avivoca*, was afforded when viable eggs were obtained in the laboratory from two gravid females, shortly following their capture in a gum-cypress swamp in eastern Louisiana. Special attention was given to the changes in the egg envelopes during development, the mechanism of hatching, size-staging relationships, the differentiation of the mouthparts, and the pigmentary patterns at various larval periods.

The characteristic swelling of the jelly mass following fertilization is due to the absorption of water by the soft, outer (second) envelope. The latter is coated by a pliant, adhesive jelly film, which becomes progressively thinner as the second envelope swells. A taut, inner (first) envelope does not imbibe water, ultimately ruptures, and forms a cap-like aggregate on one side of the vitelline membrane.

No strong muscular contractions accompany the hatching of the embryo from its encapsulating membranes, nor is the pressure of vitelline fluid effective in propelling the embryo. The gradual, gliding motion of the embryo suggests that its emergence is achieved by the activity of ectodermal cilia.

Satisfactory criteria are available for the division of the developmental period into discrete, identifiable stages. Data on absolute body dimensions must be interpreted with caution, since the larvae vary in size at different developmental stages and under different environmental conditions.

Characters of diagnostic value are the configuration of the oral disc (labial tooth formula: 2/3) and the pattern of pigmentation. Prominent pigmentary features of the tadpole are a light preorbital stripe, a butterfly-shaped interorbital mark, and a series of vivid red "saddles" on the dorsolateral portion of the tail musculature. The usefulness of these color patterns in identification is enhanced by an appreciation of ontogenetic changes, physiological activities of the constituent chromatophores, and the effects on the pigments of formalin preservation.

The eggs, embryos and larvae in our sample from Louisiana were contrasted with those from Tennessee examined by Parker (1951) and from Florida studied by Hellman (1953).

Literature Cited

Gosner, Kenneth L. 1960. A simplified table for staging anuran embryos and larvae with notes on identification. *Herpetologica 16:183–190.*

Hellman, Robert E. 1953. A comparative study of the eggs and tadpoles of *Hyla phaeocrypta* and *Hyla versicolor* in Florida. *Publ. Research Div., Ross Allen's Reptile Inst. 1:61–74.*

Limbaugh, Beverly A. and E. Peter Volpe. 1957. Early development of the Gulf Coast toad, *Bufo valliceps* Wiegmann. *Am. Mus. Novitates No. 1842:1–32.*

Mittleman, Myron B. 1945. The status of *Hyla phaeocrypta* with notes on its variation. *Copeia 1945:31–37.*

Noble, G. Kingsley. 1926. The hatching process in *Alytes, Eleutherodactylus* and other amphibians. *Am. Mus. Novitates, No. 229:1–7.*

Parker, Malcolm V. 1951. Notes on the bird-voiced tree frog, *Hyla phaeocrypta. J. Tenn. Acad. Sci. 26:208–213.*

Rugh, Roberts. 1934. Induced ovulation and artificial fertilization in the frog. *Biol. Bull. 66:22–29.*

Shumway, Waldo. 1940. Stages in the normal development of *Rana pipiens.* I. External form. *Anat. Rec. 78:139–144.*

Smith, Philip W. 1953. A reconsideration of the status of *Hyla phaeocrypta. Herpetologica 9:169–173.*

Taylor, A. Cecil and Jerry J. Kollros. 1946. Stages in the normal development of *Rana pipiens* larvae. *Anat. Rec. 94:7–23.*

Viosca, Percy. 1923. Notes on the status of *Hyla phaeocrypta* Cope. *Copeia 1923:96–99.*

———. 1928. A new species of *Hyla* from Louisiana. *Proc. Biol. Soc. Washington 41:89–92.*

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Herpetological Notes

A NEW LOCALITY RECORD FOR *PSEUDEMYS SCRIPTA ELEGANS* IN MICHIGAN.—Edgren (1943, *Copeia No. 4, p. 249*) was the first to call attention to the occurrence of *Pseudemys scripta elegans* in Michigan on the basis of two specimens from Crystal Lake, Muskegon County, in southwestern Michigan. The assumption was made that this turtle had been introduced by Boy Scouts who have camps on this lake. The absence of specimens from south of Muskegon and nearer the natural occurrence of this species in the Kankakee drainage in Indiana was thought to preclude the possibility of a natural range extension. Edgren (1948, *Nat. Hist. Misc., No. 22, Chicago Acad. Sci. p. 1*) gives six additional records, three more from Crystal Lake, one from Duck Lake, one from near Whitehall (all in Muskegon County), and one from the North Branch of White River in Oceana County, Michigan. He suggests that these records, excluding those from Crystal Lake, represent an extension of the range of this introduced population.

The range of *P. s. elegans* (Schmidt, 1943, *Check List of North American Amphibians and Reptiles, 6 ed., p. 103*) does not include Michigan, apparently because Edgren's records were considered to represent an introduced population. Conant (1958, *A Field Guide to Reptiles and Amphibians, Map 24*) depicts the natural range of the species and indicates an isolated colony in western Michigan and another in south-central Ohio.

This note concerns the occurrence of another population of *P. s. elegans* in Michigan, this one in Oakland County in the southeastern part of the state. Three specimens were collected from Cranbrook Lake, Bloomfield Hills, two in May, 1958, and a third in May, 1959. Two of these specimens were quite large, measuring seven and eight inches, respectively. A fourth specimen collected in 1959 was one of the two specimens originally taken in May, 1958, which were subsequently released in June of that year.

Cranbrook Lake is on the grounds of the Kingswood School, Cranbrook. The proximity of this lake to this school again suggests that this is an introduced population. However, the recapture of one specimen the year following its original capture indicates that this species is able to survive the severe winters in this latitude and may eventually become established in this area.—HARRY GORDON AND JAMES A. FOWLER, *Cranbrook Institute of Science, Bloomfield Hills, Michigan*

INTERTIDAL FISHES AS FOOD OF THE COMMON GARTER SNAKE.—Cowan and Hick (1951, *Trans. Royal Soc. Canada, Ser. 3, 45*:19–60) and Carl (1951, *British Columbia Provincial Museum, Handbook No. 3, 65 p.*) stated that the garter snake, *Thamnophis*, fed upon small fish in tide pools along the coastal regions of British Columbia, Canada, but no mention was made about the kinds of fish which were ingested. Stebbins (1954, *Amphibians and Reptiles of Western North America*) did not indicate that *Thamnophis sirtalis* feeds intertidally, but that it fed upon fresh-water and terrestrial items along the Pacific Coast. Hebard (1951, *Herpetologica 7:61–2*) studied the food habits of the garter snakes in the Puget Sound area and found "that *sirtalis* feeds almost entirely on aquatic animals, particularly frogs and salamanders", but did not mention *sirtalis* feeding intertidally.

While visiting the University of Washington's Friday Harbor Laboratories on San Juan Island during the summer of 1960, I found that intertidal feeding by the garter snakes was common knowledge among the investigators, but no one had made observations as to the types of fishes these snakes were feeding upon or where or when in the intertidal zone these fish were being taken.

Collections were made at frequent intervals in the vicinity of the Friday Harbor Laboratories during July and August during the lower low tide for a particular day by walking along the water's edge and then walking farther up in the intertidal zone, thus covering the entire zone by systematic walking parallel to the water's edge. When a snake was found, it was collected by hand and placed in a jar. All snakes were preserved within one-half hour by injecting 40 per cent formalin into the coelom and placing the snake in 10 per cent formalin for several days for hardening. Then the contents of the entire digestive tract were removed by cutting the ventral mid-line of the snake and were placed in 10 per cent formalin.

All snakes collected in the intertidal zone were *Thamnophis sirtalis*, although *T. elegans* and *T. ordinoides* do occur above the intertidal zone on San Juan Island. Only fishes were found to have been ingested by the reptiles collected intertidally. Ten specimens were collected over the two-month period in the intertidal zone. Of these, five had fish in the digestive tract, the other five had empty digestive tracts. The three species of fish represented were: cockscomb, *Ano-*

TABLE 1. SUMMARY OF INFORMATION ON *Thamnophis sirtalis* AND CONTENTS OF DIGESTIVE TRACT[1]

Specimen Number	Date	Time	Tide	Length of Snake[2] (mm)	Contents	Total Length of Fish (mm)
1	7 Jul 1960	0928	−2.4 ft.	781–610	*Anoplarchus purpurescens*	82
2	"	"	"	630–485	*Gobiesox maeandricus*	76
3	"	"	"	551–425	*A. purpurescens*	89
					"	29
					"	26
					Xiphister atropurpureus	30
4	"	"	"	534–390	Empty	—
5	8 Jul 1960	1014	−2.8 ft.	455–350	*A. purpurescens*	81
6	10 Jul 1960	1146	−2.5 ft.	530–425	Empty	—
7	8 Aug 1960	1129	−1.4 ft.	594–453	*A. purpurescens*	81
					"	72
					"	41
8	"	"	"	586–467	Empty	—
9	"	"	"	269–205	Empty	—
10	20 Aug 1960	0940	−0.2 ft.	484–357	Empty	—

[1] Only positive collecting trips listed.

[2] The first number indicates total length, the second number snout-vent length.

plarchus purpurescens; black prickleback, *Xiphister atropurpureus*; and the northern clingfish, *Gobiesox maeandricus*. (All names are from *American Fisheries Society, Special Publication No. 2, 102 p., 1960*) Data on the snakes and the contents of the digestive tract are presented in Table 1.

Collecting was successful only during the minus tides. During the minus tides, the rocks covered with sea lettuce, *Ulva*, are exposed; and the three species of fish found in the snake's digestive tract inhabit mainly this area. One snake, Specimen No. 2, which was the only one seen actually feeding, was definitely in the rocky area covered with *Ulva*. The high frequency of empty stomachs might be due to the fact that collections were begun as soon after the tide had reached its lowest point, and the snakes may have been intercepted before they reached the fishes.

Collections of fish made in 'the vicinity of where the snakes were collected and at another similar habitat indicated that the cockscomb was the most abundant species. For example, on July 7, 1960, hand picking under and around rocks, fifty cockscomb, eight northern clingfish and four black pricklebacks were collected. Eight cockscomb, one black prickleback and one northern clingfish were found in the digestive tract of the five *T. sirtalis*. Of course, with the small number of specimens represented, it is difficult to make inferences as to preference, if any. But by using the data at hand there appears to be no preference between *A. purpurescens*, *X. atropurpureus* and *G. maeandricus*, the frequency being about the same in the stomach contents as found by hand picking.

In the intertidal areas around the Friday Harbor Laboratories, the tidepool sculpin, *Oligocottus maculosus*, is very abundant in the upper and lower tidepools. Reports given to the author indicated that the snakes also feed upon these fish, but this has not been verified in any of the collections made. One thing is clear, the *T. sirtalis* collected by-passed great numbers of tidepool sculpins in order to reach the habitat where the blennies and clingfish lived. This by-passing might be due to preference (i.e., the spines found on the preopercle and opercle could be and probably are offensive), or the snakes are unable to capture the sculpins in this habitat of open tidepools. This seems unlikely since the blennies and clingfish are found under rocks. These fishes live in an area covered with sea lettuce which is exposed only at the minus tides, and it is believed that they would be as difficult to capture as the sculpins. Thus, the reptiles are able to feed on these fishes only during the several days of the bi-weekly period per month when this habitat is exposed, indicating periodicity in the feeding behavior of this sub-population of intertidal feeders.—BILLY S. BATTS, *College of Fisheries, University of Washington, Seattle, Washington. Contribution No. 132 from the College of Fisheries, University of Washington.*

FEEDING BEHAVIOR IN ADULT *TARICHA*.—During the spring of 1959, between 28 February and 27 March, 35 *Taricha rivularis* and 20 *T. granulosa* were collected from sympatric breeding populations in Pepperwood Creek, a tributary of the Wheatfield Fork of the Gualala River, Sonoma County, California and their stomach contents examined. The animals

were all adults in breeding condition and were collected both on land and in the water. The stomachs and their contents were placed in 70% alcohol within 30 minutes of the time of capture and the contents examined within 8 hours.

In addition to the morphologic features that distinguish these species, there are also a number of behavioral differences. *Taricha rivularis* emerges from underground following the onset of the fall rains and enters the water to breed when the stream begins to recede from winter flood level. After breeding in March and April, the animals leave the water and are not seen again until the following fall (Packer, 1960, *Ecol. 41:509–517*). *Taricha granulosa* is much more aquatic, occasionally entering the water somewhat earlier than *rivularis* and normally remaining there throughout the summer, leaving it only when the winter floods begin. The two species breed at the same time, and both leave the water when it rains during the breeding season. These species also differ in their feeding habits.

The food taken by *granulosa* has been described by a number of authors and their results are summarized by Stebbins (*Amphibians of Western North America. 1951. p. 18–19*). The findings in the present study of this species are similar, with adults or larvae of 29 terrestrial and 6 aquatic organisms being found (Table 1).

While the stomachs of the two species contained organisms common to both (15—all terrestrial), the stomachs of *rivularis* contained 25 terrestrial forms only. This was true of those that had recently entered the water as well as those collected on land. Animals that had been in the water for some time had empty stomachs.

Insects comprised the main component of the animal's diet, both in number of species and number of individuals, but due to the relatively small sample studied it is not possible to state which forms are the most important. It is clear, however, that both species are opportunistic feeders even though *rivularis* restricts its feeding to land. With the exception of those *rivularis* with empty stomachs, all specimens studied also contained sand or small gravel and some plant debris in their digestive tract. This material was apparently ingested incidental to the capture of food.

TABLE 1. NUMBER OF SPECIES OF ORGANISMS (TERRESTRIAL OR AQUATIC) FOUND IN THE STOMACHS OF *Taricha granulosa* AND *T. rivularis*

Food source	*Taricha granulosa* only	Common to both	*Taricha rivularis* only
Terrestrial	14	15	10
Aquatic	6	0	0

TABLE 2. COMPARISON OF FREQUENCY OF EMPTY OR FULL STOMACHS IN RELATION TO COLLECTING SITE (WATER OR LAND)

Stomach condition	*T. granulosa*		*T. rivularis*	
	Water	Land	Water	Land
No. full	8	12	2	19
No. empty	0	0	13	1
Total	8	12	15	20

As shown in Table 2, all of the *granulosa* examined contained food. Of the 20 *rivularis* collected on land only one had an empty stomach, while 13 out of the 15 collected in the water had no food in the gut. The two which did contain food had evidently just entered the water, since their skin was still rough and particles of dirt were adhering to their bodies. These observations reveal a clear difference in feeding behavior which reflects their habitat preferences—*granulosa* being considerably more aquatic than *rivularis*—and one not associated with their breeding physiology, since when "forced" temporarily from the stream during periods of rainfall both resume feeding on land.—WAYNE C. PACKER, *Department of Zoology, University of Western Australia, Nedlands, W. A., Australia.*

TYPE LOCALITY RESTRICTIONS IN NOMENCLATORIAL PROCEDURE.—In a recent paper on the lizards related to *Cnemidophorus sackii*, Zweifel (1959, *Bull. Am. Mus. Nat. Hist.* 117:61–116) has commented upon several different aspects of the problem of restriction of type locality both as a biological and a nomenclatorial problem. I wish to point out several facts of some significance in evaluation of similar problems in the future.

Zweifel (*Ibid.* p. 71) states: "The question at hand is the legality of the original restriction of the type locality of *communis* to Colima by Smith and Taylor, and the rejection of this restriction by Peters." To support this statement, Zweifel quotes the rules of nomenclature adopted in 1953 by the XIVth Congress of Zoology in Copenhagen, which specify that the rule of priority shall apply with regard to type locality restriction. Since the results of the XVth International Congress of Zoology, which met in London in 1958, have not as yet been made available, one cannot expect Zweifel to know that the Colloquium on Nomenclature took action on the insertion of regulation of type locality into the *Règles*. I attended these meetings,

however, and objected to the inclusion of any such regulation on the grounds that the type locality of a species is not a question of nomenclature, but of the biology of the species, and as such was not subject to the rules. My arguments are published in detail in the Agenda Papers of the Colloquium (Peters, 1958, *Bull. Zool. Nomen.* 15:1189–92). In the J. C. Bradley draft (1957, *Bull. Zool. Nomen.* 14: 1–90) of the *Règles*, Article 17, entitled "Localities of Origin," dealt entirely with the question of designation and restriction of type localities. On July 13, 1958, a majority vote of the Colloquium deleted Article 17 from the *Règles*, and replaced it with a recommendation to be inserted elsewhere. This recommendaton (72E, "Type Localities" in the rules recently drawn up by Curtis Sabrosky and his co-workers, which will have been published by the time this note appears) states in effect that the designation and/or restriction of a type locality is to be determined on one or more of the following bases: original description; data accompanying the type specimens; collectors' notes, itineraries, letters, conversation, or other personal communication; and, as a last resort only, localities within the known range of the species or from which specimens supposed to belong to the species in question are known to have been taken. The recommendation also states that such a restriction or designation that is not consistent with all available information on the species should not in any way be binding upon subsequent authors.

Zweifel's acceptance of the restriction by Smith and Taylor (1950, *Univ. Kansas Sci. Bull. 33:328*, and 1950, *Bull. U. S. Natl. Mus. 199, p. 182*) of the type locality of *Cnemidophorus sacki communis* to Colima on the basis of the *Règles* is not valid. Were it so, all of the other wholesale restrictions made at the same time by Smith and Taylor would be equally valid. However, Zweifel's additional work on the biqlogical segment of the problem as a consequence of re-discovery of the cotypes of *communis*, and his analysis of specimens from Guadalajara in regard to the likelihood that I. I. Major's specimens actually came from there, are precisely the kind of information necessary under the new recommendation to permit review and change of previous restrictions of type locality. Thus, while I continue to reject Smith and Taylor's restriction of the type locality to Colima, I accept the data used by Zweifel to make the same restriction, and to show that my restriction to Guadalajara is untenable.

Slavish obedience to a law of priority within the domain of nomenclature is bad enough and results all too often in the destruction of well-known names. Similar obedience with regard to type localities would be most unfortunate, and we can rejoice that the Colloquium saved us from it.—JAMES A. PETERS, *Department of Biology, San Fernando Valley State College, Northridge, California.*

NATURAL DISPERSAL OF THE SALAMANDER *ANEIDES AENEUS*.—On April 17, 1960, John Cralley, Karel Liem and one of us (KLW) collected 2 adult *Aneides aeneus* Cope and Packard freshly killed by automobiles on a paved road in Cumberland Gap State Park, Whitley Co., Kentucky. Rain had been falling for approximately one to one and a half hours when the specimens (within 20 feet of each other) were found. The nearest rocky ledges were 50-plus feet away.

This constitutes, as far as the authors can determine, the first record of *A. aeneus* actually moving any distance from suitable habitat over man-made terrain.

Gordon (1952, *Am. Midland. Nat. 47: 684, Table 3C*) records the movement of 26 marked individuals, only 2 (an adult male and an immature) of which were recaptured at a distance greater than 12 feet. The two longer movements, 300 and 350 feet, were within a cove hardwoods forest between granite outcrops. With the exception of these two individuals, Gordon's data (*Ibid.* Fig. 6) indicate little movement on the part of any individual except during the dispersal periods of the annual cycle. It is probable that the two dead individuals represent part of the post hibernation and dispersal movement of the population inhabiting the ledge adjacent to the highway.—KENNETH L. WILLIAMS, *Museum of Natural History and Department of Zoology, University of Illinois, Urbana* AND ROBERT E. GORDON, *Department of Biology, University of Notre Dame, Notre Dame, Indiana.*

LONGEVITY OF A CAPTIVE *CONSTRICTOR CONSTRICTOR*.—This report is to place on record the death, on February 15, 1961, of a Central American *Constrictor constrictor* which had been maintained alive in this laboratory for 24 years and nine months. This snake is the subject of Figure 253 in C. P. Hickman, 1955, *Integrated Principles of Zoology*, C. V. Mosby, St. Louis. The specimen was purchased from the Ross Allen Reptile Institute by Mr. E. Gifford Black in mid-May of 1935. Mr. Black was obliged to dispose of his specimens almost exactly a year later, and the *C. constrictor* was acquired by this department in mid-May of 1936. There is thus an authenticated life span for this snake totaling 25 years and nine months, which ex-

ceeds the maximal age for this species given by Perkins (1952, *Copeia pp. 280–281*; 1953, *p. 243*; 1954, *pp. 229–230*; 1955, *p. 262*). It also stands in the upper part of the range of 20 to 30 years given as the potential life span of snakes in general by Pope (1956, *The Reptile World*, Alfred A. Knopf, New York). When acquired by this department after one year of captivity, the snake was 152 cm in length; at death it was 246 cm long and weighed 4536 grams.—ALBERT E. REYNOLDS, *Department of Zoology, DePauw University, Greencastle, Indiana.*

A NEW HYLID GENUS FROM THE LOWER MIOCENE OF FLORIDA.—The Thomas Farm, Gilchrist County, Florida has previously yielded most of our scanty information regarding anurans of the Miocene of North America. Extinct forms include *Bufo praevius* Tihen, and *Hyla goini* Auffenberg. Remains of *Scaphiopus, Gastrophryne,* and *Rana* have been collected from the above locality, but none have been identified to species with any degree of certainty.

Material recently collected by the Florida Geological Survey from the Thomas Farm contains the ilium of a distinct new frog of the family Hylidae which is described as

Proacris *gen. n.*

Type of genus.—*Proacris mintoni* new species

Diagnosis.—Fossil ilium distinctly separable from those of fossil and Recent *Acris* Duméril and Bibron, *Hyla* Laurenti and *Pseudacris* Fitzinger in having acetabular cup much enlarged and almost entirely encroaching on the much reduced ventral acetabular expansion, and in having pronounced ridge just anterior to dorsal protuberance.

Proacris mintoni *sp. n.*

Fig. 1

Holotype.—Left ilium FGS V-5950. From Hawthorne formation, Lower Miocene, Arikarean; Thomas Farm, Gilchrist County, Florida. Collected by Dr. Pierce Brodkorb November 27, 1959.

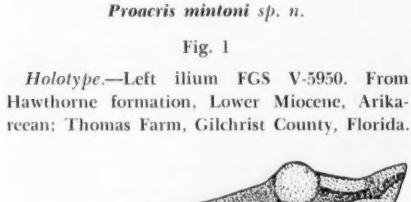

Fig. 1. FGS V-5950, holotype left ilium of *Proacris mintoni gen.* et. sp., *n.* L. Miocene, Thomas Farm, Gilchrist County, Florida.

Diagnosis.—Differs as the genus.

Etymology.—The species is named in recognition of the herpetological contributions of Dr. Sherman A. Minton.

Discussion.—The fossil ilium is definitely referable to the family Hylidae by the following strong characters: (1) The ilial shaft of the fossil is without a dorsal crest. A well developed dorsal crest is present in the Ranidae, and in the Pipinae of the Pipidae. A moderately developed dorsal crest is present in the Leptodactylidae, and in the Xenopinae of the Pipidae. (2) The dorsal protuberance of the ilium is produced dorsolaterally, and is well developed, round, and smooth. The dorsal protuberance is produced dorsally in the Pelobatidae, Bufonidae, and Microhylidae. The protuberance is weakly developed, roughened, or notched in the Pelobatidae, well developed, but roughened and often irregular in shape in the Bufonidae, and well developed, but smooth and triangular in the Microhylidae.

In the study of the generic relationships of the fossil the following Recent hylid skeletons were studied: *Acris gryllus* (8), *Hyla cinerea* (4), *Hyla crucifer* (4), *Hyla femoralis* (2), *Hyla gratiosa* (3), *Hyla phaeocrypta* (2), *Hyla septentrionalis* (1), *Pseudacris nigrita* (12), *Pseudacris triseriata* (1), and *Pseudacris ornata* (1). Anatomical terminology follows Auffenberg (1956, *Breviora 52:1–11*), and Holman (1959, *Copeia 2:96–102*).

The enlarged acetabular cup is the most striking character of *Proacris*. Recent *Acris* approaches the condition found in the fossil, but by no means equals it, whereas in *Hyla* and *Pseudacris* the posterior border of the relatively small acetabular cup ends well anterior to the posterior border of the well developed ventral acetabular expansion. The elevated ridge just anterior to the dorsal protuberance in *Proacris* is unique among Recent and fossil Hylidae studied. The fossil appears closest to *Acris* in the angular development of the ventral acetabular expansion. This expansion tapers uniformly to a point in *Hyla*, and tapers uniformly to a point or is rounded in *Pseudacris*. The fossil ilium is similar in size to the ilia of eight Recent *Acris gryllus* from Gainesville, Florida.

The fossil may well be ancestral to Recent *Acris*, although there remains the possibility that *Proacris* represents an archaic hylid line that is not particularly close to the ancestry of living forms. Auffenberg (1956, *Breviora 52:1–11*) has suggested that *Hyla goini* from the Lower Miocene of the Thomas Farm may be ancestral to both *Hyla* and *Pseudacris*, yet *Scaphiopus,*

Bufa, Gastrophryne, and *Rana* from the above locality are indistinguishable from the living genera. It thus seems possible that the Hylidae are a comparatively plastic and rapidly evolving group.—J. ALAN HOLMAN, *Department of Biology, Howard College, Birmingham, Alabama.*

THE WESTERN LESSER SIREN IN MICHIGAN.—Two specimens of the Western Lesser Siren, *Siren intermedia nettingi,* were discovered dead on the shore of Saddle Lake (T.IS.R.15W., Sections 15 and 16), Van Buren County, Michigan on June 11, 1958. The lake had been treated with rotenone (1 ppm.) the previous day to remove a carp population. The sirens (University of Michigan Museum of Zoology M118525 and M118526) measured 223 mm. and 151 mm. in total length after preservation and constitute the first known record of this genus from Michigan. Several additional sirens reportedly were found dead at Saddle Lake during the week after treatment.

Pope (1944, Amphibians and Reptiles of the Chicago Area, *Chicago Natural History Museum: 1–275*) stated that the only record of the Western Lesser Siren from the Chicago area "is based on a small specimen from Hebron, Porter County, Indiana and marks the northernmost point reached by this subspecies," Smith and Minton (1957, *Amer. Mid. Nat. 58:341–51*) observed that this "...southern species exhibits distributional patterns correlated with stream drainage" and that "...*Siren intermedia*... [has] fairly extensive ranges along the major rivers of central Illinois and in the lakes of northern Indiana, especially those associated with the Kankakee and Tippecanoe river systems."

Although Saddle Lake is nearly 300 acres in area, it has quiet, shallow, weed-choked bays which apparently were suitable habitats for sirens. The lake is 43 miles north of the Michigan-Indiana border and drains via Barber Creek northward to the Middle Fork of the Black River in Allegan County. The Black River in turn flows southward into Van Buren County and enters Lake Michigan at South Haven.

There are two possible natural routes by which the siren could have spread to Michigan. In St. Joseph County, Indiana, the northernmost part of the Kankakee drainage adjoins the St. Joseph River drainage; the St. Joseph River flows northward into the State of Michigan, and empties into Lake Michigan at Benton Harbor, at a point only 23 miles south of the mouth of the Black River. A second possible route would be directly from the St. Joseph River to the Paw Paw River at Benton Harbor. In Van Buren County the Paw Paw River drainage approaches the South Branch of the Black River. There is a distinct possibility that the siren was introduced into Saddle Lake by an angler.—JOHN E. WILLIAMS, *Institute for Fisheries Research, Michigan Department of Conservation, Hastings, Michigan.*

AN ADDITIONAL NOTE ON THE EAR OF *HOLBROOKIA MACULATA.*—Subsequent to the initial description of the middle ear of *Holbrookia maculata* (Earle, 1961, *Copeia:68–74*) several serial sections of adults of this species have been examined. In all sections of adults the extracolumellar process is dorsoventrally lengthened to form an insertion plate which is enveloped in the tympanic membrane posterior to the quadrate. An extracolumellar ligament extends ventrally from the processus paroticus and passes anterolaterally beneath the arched dorsal portion of the quadrate. This ligament then extends ventrally over the insertion plate of the extracolumella.

The glossopharyngeal nerve of *Holbrookia maculata* does not pierce the secondary tympanic membrane as erroneously reported, but emerges through only the connective tissue of this membrane.—A. M. EARLE, *Dept. of Biology, Regis College, Denver, Colo.*

THE SOFTSHELL TURTLE, *TRIONYX SPINIFER,* INTRODUCED AND ESTABLISHED IN NEW JERSEY.—Evidence has gradually accumulated indicating that the spiny softshell turtle is established and reproducing in one of the stream systems of southern New Jersey. Further, I have learned that the original stock was introduced from Indiana during 1910.

The first two softshells brought to my attention, each from a different locality, were not preserved, under the illusion that they represented escapes or recently liberated turtles. Both were measured, however, and exhibited in the Philadelphia Zoological Garden. Later, when hatchlings were discovered, an investigation was instituted the results of which are summarized herewith. Measurements refer to the maximum (straight-line) length of the carapace. Initials and numbers designate those deposited in the collection of the American Museum of Natural History. The localities are in Salem County, New Jersey. Except as noted, all turtles are from Kean's Lake at the town of Elmer.

The following specimens were caught on the dates indicated: July 23, 1949, ♂, 235 mm., taken by hook and line. July 1, 1954, ♀, 380 mm., Palatine Lake, near Palatine, found on the lake shore under circumstances that, in retrospect, suggest she may have been nesting. September

21, 1959, three hatchlings, two preserved (AMNH 85401–2), both 41 mm., in a shallow, sand-and-pebble-bottomed area along the dam breast of Kean's Lake. May 30, 1960, a small specimen (AMNH 85403), 37.5 mm., that may have hatched the previous autumn or hibernated in the shell or nest. June or July, 1960, ♂ (AMNH 85404), 151 mm. All of the above were received at the Philadelphia Zoo. In addition three large ones were taken to the Philadelphia Aquarium in 1957 by Thomas Dunn, of Pennsville, New Jersey, who obtained them along with five others in Kean's Lake while running a trap line for snapping turtles (*Chelydra*). The survivor (a female) among the three at the Aquarium had a carapace length of 348 mm. when measured February 19, 1961. Dunn told me that the smallest of the eight had a five-inch (127 mm.) shell.

According to Mr. and Mrs. E. A. Kean, of Elmer, New Jersey, the owners of Kean's Lake, softshells were introduced into their lake many years previously by a relative, Mr. John A. McKeen, who came from the Midwest on vacation each year. Fortunately, his son, Mr. Horace McKeen, of Indianapolis, recalls a number of pertinent details. The approximate time of introduction was June, 1910. He states, "My father, a native of South Jersey, was very interested in determining whether or not the softshell turtle would propagate in the ponds (now lakes) of the region. I remember distinctly he brought the turtles back from Indiana in a zinc-lined wicker basket. There were four of them, each about the size of a small plate. They were caught in the Mississinewa River, approximately nine miles northwest of Marion, Indiana."

Lakes in southern New Jersey are man made. Kean's Lake, at Elmer, is impounded by a dam across a small stream called Muddy Run. Palatine Lake, the only other locality represented by a specimen, is on the same watercourse. So also are Rainbow Lake and the lake in Parvin State Park from both of which there are verbal reports of softshells. *Trionyx* also is said to occur in Willow Grove Lake, approximately five miles overland southeast of Elmer. If the turtle reached Willow Grove Lake under its own power, a likely possibility with a half century of time involved, its route was south and then southeast from Kean's Lake downstream along Muddy Run to its confluence with the Maurice River, and then northward (upstream) to Willow Grove, a distance by water of approximately 18 miles. The Maurice River, in this portion of southern New Jersey, marks the western limits of the Pine Barrens, noted for their clear, sandy streams and acid water. Muddy Run, which traverses farming country, is well named, especially after heavy rains. It is a safe prediction that the softshell turtle will be found in other localities in the Maurice River drainage system.

The pattern variations fall within the range of the nominate subspecies, *Trionyx spinifer spinifer*, the form inhabiting Indiana. The male specimen collected July 23, 1949, is apparently the largest (235 mm.) of its race to be recorded to date. The largest male (205 mm.) I had seen previously is No. 72512 in the collection of the University of Michigan Museum of Zoology from near Never's Dam, St. Croix River, Polk County, Wisconsin.

The Academy of Natural Sciences of Philadelphia has a male of this form (ANSP 15203, carapace 154 mm.) from Cooper's Creek, Camden County, New Jersey, collected in May, 1902. Fowler, in his account of the amphibians and reptiles of the state (1907, *Ann. Rep. New Jersey State Mus. for 1906:213*), includes this specimen, also quotes other New Jersey localities cited by Cope and Abbott, and then dismisses them with the statement that the turtles "were introduced when young and apparently to stock aquaria." Other softshells, obviously introduced, have appeared in eastern Pennsylvania, among them one found on a downtown Philadelphia street. There is no evidence to indicate that colonies are established in any other localities in New Jersey or eastern Pennsylvania.

The natural range of this turtle terminates far west and north of New Jersey. The nearest localities are in streams of Mississippi drainage in western Pennsylvania and in St. Lawrence drainage in northern New York and Lake Champlain. A recent record from Rexford, Saratoga County, New York, may represent an eastward movement of the species along the Erie Canal. (See Bishop, 1923, *Copeia 125:120*, for other localities in the Albany area.)

The use of the specific name *spinifer* for the spiny softshells is in accordance with Schwartz (1956, *Charleston Museum Leaflet 26:1–21, figs. 1–3, maps 1–2*), a paper that apparently has been overlooked by a number of herpetologists. I agree with Schwartz and many others that *spinifer* and *ferox* are separate and distinct species.

For assistance in the preparation of this paper and for specimens I am indebted to all persons named above, plus Karl Bickel, Frederick R. Gehlbach, Henry W. Fowler, Wayne Frair, George Kinsley, John Russack, Roland F. Smith, and Robert G. Webb.—ROGER CONANT, *Zoological Society of Philadelbhia, Philadelphia 4, Pennsylvania.*

Ichthyological Notes

RANGE EXTENSIONS OF THE OPHICHTHID EELS, PHYLLOPHICHTHUS *XENODONTUS* AND *CIRRHIMURAENA MACGREGORI*.—Specimens of two species of ophichthid eels hitherto known only from the Hawaiian and Marshall Islands in the tropical Pacific were collected in the Indian Ocean by Dr. James E. Morrow, Jr. in 1957.

Phyllophichthus xenodontus was first described from Oahu Is., Hawaii (Gosline, *Pacific Sci. 5:298–320*, 1951). Two other specimens, one Hawaiian and one Marshallese, were later reported (Gosline and Brock, *Handbook of Hawaiian Fishes, p. 126*, 1960). In the present study one specimen (Bingham Oceanographic Collection No. 1290), 375 mm in standard length, was collected Nov. 6, 1957 during a rotenone poisoning over a coral reef flat on the northeast side of Bird Island, Seychelles at depth 1–15 feet. In agreement with Gosline's (1951) description, this specimen has a leaflike anterior nostril, which is unique among ophichthids. The dorsal fin originates over the pectoral insertion, the vomerine teeth are absent, the conical teeth in both jaws are uniserial, and the teeth on the dentary are directed laterally. Although our measurements generally agree with the proportions listed by Gosline, two of them differ, perhaps significantly: depth at anus, 3.2 per cent of standard length (*cf.* 2.2 per cent, Gosline) and cleft of mouth, 2.9 per cent (*cf.* 3.8 per cent, Gosline).

Cirrhimuraena macgregori was first described from Maui Island, Hawaii (Jenkins, *U. S. Bur. Fish. Bull. 22:422*, 1904). Fowler (*Mem. Bernice P. Bishop Mus. 10:45*, 1928) reported another specimen from Maui and Gosline (1951) reported 6 more: 4 from Oahu Is., 2 from Hawaii Is. In the present study the Indian Ocean material comprises 31 specimens, 101–211 mm in standard length: 30 (BOC 1291) were collected Aug. 21, 1957 during a rotenone poisoning at the north end of Sweat Bay, Trincomalee, Ceylon at depth 0–6 feet; one (BOC 1292) was caught on Aug. 13, 1957 with a dip net under a night light in Clappenberg Bay, Trincomalee, Ceylon. In agreement with Jenkins' description these specimens have the dorsal origin well ahead of the gill openings, elongate pectorals, and a fringed upper lip; also, in agreement with Gosline (1951) the posterior vomerine teeth are multiserial. Of the proportions calculated only the ratio, head into trunk (2.9) differs appreciably from the value (4.8) given by Jenkins. In the present study this ratio equals the head length into the distance, gill opening to anus; the reference points used by Jenkins are uncertain.—WALTER H. WEED III AND JOHN N. HOWARTH, *Bingham Oceanographic Laboratory, Yale University, New Haven, Connecticut.*

A RECORD OF THE KYPHOSID FISH *SECTATOR OCYURUS* (=*AZUREUS*) FROM THE SOCIETY ISLANDS.—While aboard a small vessel anchored about 100 feet from shore at the head of Papetoai Bay, Moorea in early 1956 a colorful fish about 15 inches long was noticed swimming slowly just below the surface. It represented a species never seen again during nearly one and one-half years of collecting fishes in the Society Islands. The fish was yellowish olive above and white below, with a bright blue band on the back on each side and a broader one along the mid-side, bordered below with yellow; the fins were yellowish. This color pattern is reminiscent of the rainbow runner, *Elagatis bipinnulatus* (Quoy and Gaimard). The fish was easily approached underwater and was speared. It was identified in the field as the kyphosid, *Sectator azureus* Jordan and Evermann (1905, *Bull. U. S. Fish Comm. 23:248, col. pl. 20*). Jordan and Evermann obtained only a single specimen from Heeia, Oahu. They remarked that the species must be very rare, adding that it was unknown to Hawaiian fishermen. Gosline and Brock (1960, *Handbook of Hawaiian Fishes, p. 194*) reported on a second specimen from the Hawaiian Islands, a 15-inch individual taken in a trap off Waianae, Oahu. They expressed the opinion that this species is an offshore form. The body shape, broadly forked tail, and color pattern certainly suggest a pelagic or semi-pelagic mode of life, quite unlike that of the drab species of *Kyphosus* which characteristically inhabit rocky shores in tropic seas and feed on algae. The Moorea specimen (Fig. 1) was sent to the George Vanderbilt Foundation at Stanford University.

Subsequently, a comparison was made of the types of *Sectator azureus* (USNM 50664, S.L. 297 mm.) and *S. ocyurus* (Jordan and Gilbert) (1882, *Bull. U. S. Fish Comm. 1:327*) USNM 29395, S.L. 278 mm.) from Panama Bay. The two fish represent the same species; the name *ocyurus* has priority. Jordan and Gilbert described *ocyurus* in the genus *Pimelepterus* Lacepède, now recognized as a synonym of *Kyphosus* Lacepède. Jordan and Fesler (1893, *Rept. U. S. Fish Comm. 17:534, 536*) erected *Sectator* for the species *ocyurus*. They characterized the genus "by the little development of the roots of the teeth and by the deeply forked caudal". The genus is monotypic.

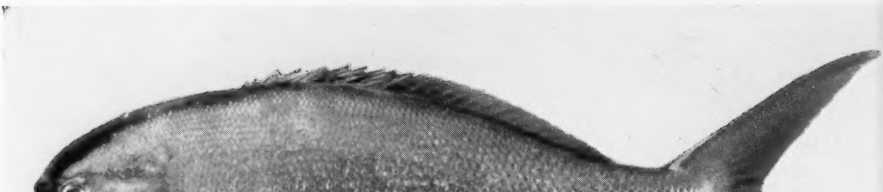

Fig. 1. *Sectator ocyurus* (Jordan and Gilbert), S.L, 310 mm., Moorea, Society Islands, Reproduced from a 35 mm. Kodachrome transparency,

Meek and Hildebrand (1925, *Field Mus. Nat. Hist. Publ. 226, Zool. Ser. 15:609*) reported three specimens of *ocyurus* from Panama Bay which were purchased in the Panama City market. Jordan and Gilbert stated that the species occasionally appears in large numbers in the market of Panama.

Sectator ocyurus has a unique distribution at the present time: eastern Oceania at 21° N and 17°30′ S on one side of the Eastern Pacific Barrier and Panama at the other side of this broad expanse of open ocean.

In recent classifications, *Sectator* is placed in the Kyphosidae, along with *Kyphosus* and *Hermosilla*. The families Scorpidae, Dichistiidae, and Girellidae are generally regarded as distinct from the Kyphosidae. These groups are closely related, and in the opinion of the author, their consideration as different families warrants a reappraisal. The inclusion of the scorpids and girellids in the Kyphosidae by Jordan and Evermann (1898, *Bull. U. S. Natl. Mus. 47:1380*) seems to have merit.—JOHN E. RANDALL, *Marine Laboratory, University of Miami.* Contribution No. 313.

ACANTHURUS DOREENSIS VALENCIENNES, A SYNONYM OF *A. PYROFERUS* KITTLITZ.—In the revision of the surgeonfish genus *Acanthurus* (Randall, *Pacific Sci.* 10:159–235, 1956), the author was unable to reach a decision concerning the validity of *Acanthurus doreensis* Valenciennes in Cuvier and Valenciennes (1835) and designated it as a doubtful species, the only one so indicated among the 33 species of *Acanthurus* known at the time (three additional species have been described in the genus, *A. melanosternon* Smith, *A. randalli* Briggs and Caldwell, and *A. chronixis* Randall).

Valenciennes' description was based on a single 8-inch specimen from Dorey Harbor, New Guinea. The snout was said to form an "S" curve like *A. glaucopareius*, the caudal was lunate and there was a whitish border on the terminal edge of this fin; the posterior half of the pectoral fin was yellowish. Considered most distinctive were the counts of the dorsal and anal fin rays, D IX,28; and A III,20.

All of these characteristics would fit *A. pyroferus* Kittlitz except the fin ray counts. This species has eight dorsal spines and 24 to 26 soft rays in the anal fin. Furthermore, there was no mention in the description of the characteristic white line on the chin beneath and extending slightly above the mouth of *pyroferus*. *Acanthurus grammoptilus* Richardson was regarded the closest of the known species to *doreensis*, although, again, the low anal fin ray count precluded the consideration of *doreensis* as a synonym.

Bleeker, Günther, Macleay, and Fowler all regarded *doreensis* as valid. Jordan and Seale (*Bull. U. S. Bur. Fisheries* 25, 1906) suggested that it might be the young of *Hepatus nigricans* (=*Acanthurus gahhm*) or *H. elongatus* (non Lacepède) (=*A. nigrofuscus*), and that the anal rays of the specimen were miscounted. Eight-inch specimens of these two species, however, would be adults.

The possibility of a miscount of anal rays remained, and the late Leon Bertin was asked to check the type (No. 7099) in the Museum National d'Histoire Naturelle in Paris. He reported the specimen as having 28 dorsal soft rays and 20 anal rays, the same counts given by Valenciennes.

In 1960 the author had the opportunity to examine the specimen, which measures 139 mm. in standard length. Surprisingly, it proved to be *pyroferus*, having eight and not nine dorsal spines and the white line on the chin. The pale terminal border on the caudal fin has largely disappeared. The enigmatic low anal ray count is the result of damage to the specimen. A section of the ventral part of the body at the posterior part of the anal fin is missing which accounts for the loss of about five rays. This damage is more easily discerned on one side of the specimen than the other.

A. doreensis is therefore referred to the synonymy of *pyroferus*. Other synonyms of this species are *armiger* Valenciennes in C. and V., *celebicus* Bleeker, *fuscus* Steindachner, and *tristis* Tickell.—JOHN E. RANDALL, *Marine Laboratory, University of Miami*. Contribution No. 322.

CARCHARHINUS NICARAGUENSIS, A SYNONYM OF THE BULL SHARK, *C. LEUCAS*.—At the time we gave our accounts of these species (*Fishes of the Western North Atlantic, No. 1, pt. 1, pp. 378–382; 337–346, respectively*) we had some doubt as to whether the Lake Nicaragua shark should stand as a valid species or be considered a freshwater *leucas*. We state: "*Nicaraguensis* very closely resembles *leucas* by the following characters. The anterior margin of the eye is posterior to the front of the mouth by a distance equal to half its own diameter in *nicaraguensis* (a little anterior to front of mouth in *leucas*); the gill openings are relatively somewhat longer in *nicaraguensis*, the third being nearly as long as the distance between the nostrils (in *leucas* the third is a little less than half that long); the free tip of the second dorsal is about two-thirds as long as its base in *nicaraguensis* (only half that long in *leucas*)."

Dr. Royal D. Suttkus, of Tulane University, sent us a young female, 685 mm in total length, taken May 1, 1960, in Rio San Juan, Atlantic drainage, ¼ mile upstream from Trinidad in fresh water. This specimen nullifies the characters supposedly separating *C. nicaraguensis* from *leucas* for (a) the anterior margin of its eye is anterior to the front of the mouth by a distance equal to ⅔ths its own diameter; (b) the third gill opening is a little less than half as long as the distance between the nostrils; and (c) the free tip of the second dorsal is half as long as the base of the second dorsal, all of which characters are present on such *leucas* material as we have examined.

Also, a jaw from a larger specimen (size not given) was received, taken near the mouth of Rio Sapoa at Lago de Nicaragua, February 13, 1960. Its dental formula is 13–1–13/12–1–12 both the upper and lower symphysis tooth being very small, as in *leucas*, nor could any of the teeth be distinguished from those of the latter. —HENRY B. BIGELOW AND WILLIAM C. SCHROEDER. *Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts.*

FIRST ONTARIO RECORD OF THE ARCTIC CHAR, *SALVELINUS ALPINUS*.—The first authentic occurrence of an arctic char from Ontario was recorded on August 13, 1960, when a large specimen was taken from the Severn River on the southwest shore of Hudson Bay. It was captured in a gill net six miles from the mouth of the river where it enters the marine environment of Hudson Bay. Roderick Miles of Fort Severn retained the fish until it could be procured for examination and subsequent preservation. Sprules (*J. Fish. Res. Bd. Canada*, 9(1), 1952) reported that the arctic char occurs as far south as the Churchill River on the west coast of Hudson Bay. Occasional specimens have been reported further south from the mouth of the Nelson River, but these are unauthenticated to date. The mouth of the Severn River on Hudson Bay is approximately 375 miles southeast of the Churchill River, and 225 miles southeast of the Nelson River. J. G. Hunter of the Arctic Unit of the Fisheries Research Board of Canada reported in personal communication that the arctic char extended at least as far south as Cape Jones, the juncture of Hudson and James Bays on the east coast in Quebec, where a small commercial fishery exists.

The arctic char is circumpolar in distribution and apparently replaces the anadromous brook trout *Salvelinus fontinalis* in the northern portion of Hudson Bay. The overlap of distribution of the two species on the west coast of Hudson Bay occurs between the Severn River to about 58° N. lat. the northernmost distribution for the brook trout (Doan, *Bull. Fish. Res. Bd. Canada, No. 79*, 1948). The distribution of both these species of *Salvelinus* is probably limited by the winter water temperatures in Hudson and James Bays which may reach a low of −1.6°C (Hachey, *Trans. Roy. Soc. Canada, Ser. 3, 48*, 1959), and summer stream temperatures in excess of 80°F in some rivers during the hottest portion of summer (unpublished data recorded by the author for the Attawapiskat River, 1957).

The arctic char from the Severn River measured 838 mm (33.0 inches) fork length, and 767 mm (30.2 inches) standard length. This was one-half inch longer than the longest char recorded by Sprules (*op. cit.*) for the west coast of Hudson Bay, although a larger but unverified record is

given in his paper. An 825 mm (32.5 inch) char is reported by Grainger (*J. Fish. Res. Bd. Canada, 10(6)*, 1953) from Frobisher Bay, Baffin Island. Andrews and Lear (*J. Fish. Res. Bd. Canada, 13(6)*, 1956 recorded a 764 mm (30.1 inch) specimen from northern Labrador. Hunter (personal communication) reports an 825 mm (32.5 inch) male as the largest of 270 arctic char sampled in Maguse Lake on the west coast of Hudson Bay.

The char taken from the Severn River was almost completely eviscerated before it could be weighed, and dressed out at 11.75 pounds. An estimated live weight was obtained by establishing a coefficient of condition for 10 specimens (5 males, 5 females) taken from the west coast of Hudson Bay (Sprules, *op. cit.*) between August 13 and September 10, and applying this figure to the Severn River specimen. Unfortunately, the males and females in Sprules' sample could not be separated, so the rather high condition factor of 4.5 was obtained for both sexes from this sample which would be expected as spawning time was approaching. When this figure was applied to the specimen from the Severn River which was taken at the same time of year, an estimated live weight of 15.8 pounds was obtained. The Severn River char was a male as evidenced by the posterior portions of the testes remaining in the body cavity following the partial evisceration, and the pronounced kipe.

It is possible that the arctic char has a more southerly distribution pattern in Hudson and James Bays than is commonly recorded, although the Cree Indians of the West Coast from Fort Severn south to Moosonee do not have a specific word in their dialect to denote the char. Most of the gill netting and seining by the natives is concentrated in the rivers or along the shallow and warm coastal flats on the incoming tide. It is possible that the arctic char extend their summer range into the deeper and colder waters of southern Hudson Bay and James Bay where little, if any, netting has taken place.

The identification of the specimen taken at Fort Severn was verified by Dr. W. B. Scott, Curator of Fishes at the Royal Ontario Museum, where it is now housed (Cat. No. 21062). We wish to acknowledge gratefully information made available pertaining to the size and distribution of the arctic char in Hudson Bay by Dr. W. B. Scott and Mr. J. G. Hunter—R. A. Ryder, *Fish and Wildlife Branch, Ontario Department of Lands and Forests, Sioux Lookout, Ontario.*

SYNONYMY OF THE ATLANTIC OCEAN FILEFISH *ALUTERA HEUDELOTII* HOLLARD.—Four species of the genus *Alutera* (Monacanthidae) are known to occur in the Atlantic Ocean: 1) *Alutera monoceros* (Linnaeus 1758) is a world-wide species, occurring in tropical and temperate regions of the Pacific and Indian Oceans and in both the eastern and western Atlantic Ocean. It has a relatively high number of dorsal and anal fin rays (D. 46–50, A. 47–52). 2) *Alutera scripta* (Osbeck 1765) has a world wide distribution similar to that of *A. monoceros*, occurring in both the eastern and western Atlantic Ocean. It also has a relatively high number of dorsal and anal fin rays (D. 43–49, A. 46–52). 3) *Alutera schoepfii* (Walbaum 1792) occurs only in the western Atlantic, from Nova Scotia to Brazil, in the West Indies, and at Bermuda. It has a relatively low number of dorsal and anal fin rays (D. 32–39, A. 35–41). 4) *Alutera heudelotii* Hollard 1855, occurs in both the eastern and western Atlantic, from Massachusetts to Brazil and at Bermuda, and from Angola to Cape Blanco, Spanish Western Sahara. It also has a relatively low number of dorsal and anal finrays (D. 34–41, A. 38–44).

Alutera monoceros and *A. scripta* can be distinguished from the other two species by several characters, including their relatively high numbers of dorsal and anal fin rays, and are not considered further here.

Alutera punctata Cuvier (by Agassiz in Spix 1831, type locality Brazil) is a nominal species that has recently been shown to be a synonym of *A. schoepfii* (type locality New York) by Berry and Vogele (in press, *Fish. Bull. U.S. Fish and Wildl. Serv.*). *A. punctata* has been recorded from the eastern Atlantic (as by Cadenat, 1937, *Revue des Travaux Office peches maritimes, 10(4):530*, fig. 58; and Poll, 1959, *Exped. Oceanogr. Belge Eaux Cotieres Africaines de l'Atlantique Sud, 4(3B):245, fig. 82*), but these records all apparently refer to *A. heudelotii*. We have seen no specimens of *A. schoepfii* (= *A. punctata*) from the eastern Atlantic; and where published descriptions of this form are adequate, they can be attributed to *A. heudelotii*.

The ontogenetic changes in *A. heudelotii* and *A. schoepfii* and the differences between these two species have been described by Berry and Vogele (*op. cit.*). The spines on the body scales are much smaller and more numerous in *A. heudelotii* giving a "velvety" feeling to the touch. The dorsal spine of *A. heudelotii* is shorter and stouter and has larger barbs, especially between 40 and 140 mm S.L. (Standard Length). The eye to dorsal spine distance of *A. heudelotii* is much smaller (4.6 to 6.6% S.L.) on specimens larger than 100 mm S.L.

The synonymy of *Alutera heudelotii* is recorded for the first time as follows:

Aluterus Heudelotii Hollard, 1855, Annales des Sciences Naturelles, *Zoologie, Ser. 4*, 4: 13 (type locality, Senegal; holotype in Museum d'Histoire Naturelle Paris, no. B. 1947).

Monacanthus (*Aluteres*) *fuscus* Fischer, 1885, Jahrb. Hamburg. Wiss. *Anstalten, 2: 75, pl. II, fig. 6* (type locality Cameroon; holotype destroyed, originally in Naturhistorischen Museum in Hamburg, no. 3943).

Aluteres blankerti Metzelaar, 1919, Report on the fishes, collected by Dr. J. Bocke. . . , *Firma Belinfanti, The Hague, p. 295, fig. 64* (type locality, Cape Blanco; types in Zoologisch Museum Amsterdam, no. 102359).

Alutera ventralis Longley, 1935, *Carnegie Inst. Washington Pub., Year-book, 34: 68* (type locality, Tortugas, Florida; types in U.S. National Museum, nos. 109177–8).

The holotype of *A. heudelotii*, 85 mm. S.L., was originally described as having small scale spines that were smooth to the touch and a strong dorsal spine armed with spines (Hollard 1885:113). The illustration of the holotype of *A. fuscus*, estimated to 87.2 mm. S.L., shows a stout and strong-barbed dorsal spine, a characteristic arch in the ventral profile of the body, and a small eye to dorsal spine distance (Fischer, 1885, pl. II, fig. 6). The illustration of the holotype of *A. blankerti*, 123 mm. S.L., shows the pigment pattern characteristic of this size fish (Metzelaar, 1919, fig. 64). The holotype of *A. ventralis*, 78.5 mm S.L., has been examined (by Berry) and has a short, stout, strong-barbed dorsal spine, small and close-set spines on the body scales, and the characteristic arch in the ventral profile. We believe that the above names are all conspecific and represent the specimens of this form that we have examined from the eastern and western Atlantic.

Selected body proportions of the type specimens and other specimens of comparable size are given in table 1. Numbers of dorsal, anal, and pectoral rays of the type specimens and other specimens are given in table 2. Data on *A. fuscus* were determined from the original description and illustration; Dr. Werner Ladiges has informed us that the holotype has been destroyed. We are grateful to Dr. J. J. Hoedeman for information on the types of *A. blankerti*, to Madame H. Bauchot for information on the holotype of *A. heudelotii*, and to Dr. Leonard P. Schultz for the opportunity to examine the types of *A. ventralis*. Data on the eastern Atlantic specimens were recorded from specimens in the Musee Royal du Congo Belge (prior determination of Poll, *op. cit.*, p. 245–8, as *A. punctatus* and *A. blankerti*). Data

TABLE 2. NUMBERS OF DORSAL, ANAL, AND PECTORAL RAYS OF SPECIMENS OF *Alutera heudelotii* AND ITS SYNONYMS

	Alutera heudelotii Holotype	*Alutera fuscus* Holotype	*Alutera blankerti* Holotype and Paratype	Eastern Atlantic Specimens	Western Atlantic Specimens	*Alutera ventralis* Holotype
Dorsal rays						
34				1		
35				3		
36		1	1	1	1	
37			1	1	10	
38	1				21	
39					22	1
40					3	
41					1	
Anal rays						
38		1	2	1		
39					3	
40				1	15	
41				4	21	
42	1				16	1
43					1	
44					2	
Pectoral rays						
12				1	3	
13	1	1	1	4	40	1
14			1		17	

TABLE 1. STANDARD LENGTH IN MILLIMETERS AND BODY PROPORTIONS IN PERCENT OF STANDARD LENGTH OF SPECIMENS OF *Alutera heudelotii* AND ITS SYNONYMS

	Western Atlantic Specimens	*Alutera ventralis* Holotype	Western Atlantic Specimens	*Alutera heudelotii* Holotype	*Alutera fuscus* Holotype	Eastern Atlantic Specimens	Western Atlantic Specimens	*Alutera blankerti* Holotype	Western Atlantic Specimens	*Alutera blankerti* Paratype
Standard Length Range (mm.)	70.5–78.5	78.5	81.0–89.0	85	87.2	98.5	102–125	123	131–147	137
Head Length	32.9–34.6	33.6	30.1–33.7	34.1	33.4	34.0	31.3–31.8	31.7	30.2–32.7	33.6
Snout Length	27.7–27.8	27.8	26.0–28.7	31.7	28.7	29.4	27.2–27.9	26.0	26.2–28.7	30.7
Eye Diameter	8.2– 9.6	8.7	7.3– 8.4	7.4	8.5	8.3	6.4–8.1	6.5	6.3– 7.7	6.9
Eye to Dorsal Spine Distance	5.7– 6.7	5.7	5.7– 6.7	6.2	4.2	5.2	4.6– 6.6	5.7	5.2– 6.1	5.8
Body Depth	36.2–42.9	41.0	36.4–41.0		37.6	43.6	39.8–44.5	42.3	40.0–43.0	49.6

on the western Atlantic specimens were taken from the manuscript of Berry and Vogele and all measurements and counts were made as described in that work.

Six specimens of 31.6 to 324 mm S.L. from the eastern Atlantic (West Africa) were compared with data from 68 specimens of 30.5 to 240 mm S.L. from the western Atlantic (Brazil to Massachusetts and Bermuda). The distinctive pigmentation pattern in adults and larger juveniles of large, round spots and terminally rounded stripes on the head and body was noted in both groups. The proportional changes in body parts with growth, known to occur in the western Atlantic form, were demonstrated by the smaller series from the eastern Atlantic (the angular ventral body profile in smaller specimens, produced by the ventral extension of the posterior end of the pelvic bone, becoming almost flattened in larger specimens; the body depth relative to the standard length first increasing then decreasing with growth; the eye diameter and the eye to first dorsal spine distance decreasing with growth relative to the standard length). The strong barbs on the first dorsal spine and the relatively widely spaced scale spines were present in smaller specimens of both groups. The number of dorsal and anal rays were slightly less in the eastern Atlantic specimens (dorsal 34 to 36, anal 38 to 41) than in the western Atlantic specimens (dorsal 36 to 41, anal 39 to 44). The numbers of pectoral rays were generally similar (eastern Atlantic 12 to 13, western Atlantic 12 to 14). These numbers are respectively 37, 41, and 13 on a specimen recently described by one of us from the eastern tropical Atlantic (Poll, 1959, *Exped. Oceanogr. Belge Eaux Cotieres Africaines de l'Atlantique Sud, 4(3B):248*).

It seems entirely possible that for certain species of fishes having surface or epipelagic larval and juvenile stages, as *Alutera*, these stages could successfully be transported in the currents of the Gulf Stream System from off the United States to off West Africa and could then become a reproductive component of the eastern Atlantic population. The North and South Equatorial Currents might also transport similar stages from West Africa to the Americas. These features of pan-Atlantic species distributions were suggested by Nichols (1939, *Bull. Bingham Oceanogr. Coll. 7(2):5*) and were commented upon by Lachner (1955, *Proc. U.S. Nat. Mus. 105(3356):193*). If this reasoning is later proved untenable and there is actually no reproductive intermingling between the populations of the species of *Alutera* in the eastern and the western Atlantic, we would still maintain that the eastern and western Atlantic populations are specifically identical. Analysis of large series of specimens from both sides of the Atlantic may warrant the recognition of subspecies in the two areas.—FREDERICK H. BERRY, *U.S. Department of the Interior, Bureau of Commercial Fisheries, Biological Laboratory, La Jolla, California, and* MAX POLL, *Musee Royal du Congo Belge, Tervuren, Belgium.*

REVIEWS AND COMMENTS

POISONINGS BY FISH NEED SYSTEMATIC STUDY. Calling for coordination of the epidemiological, biochemical, and biological approaches, Dr. Alfred F. Bartsch and Earl F. McFarren of the Sanitary Engineering Center, U. S. Public Health Service, outlined a plan for intensive and long-range studies of poisoning caused by ingestion of intrinsically toxic fin fish, according to Public Health Reports of February, 1961. (76(2):148).

Bartsch and McFarren, who participated in an exploratory survey of fish poisoning in the Marshall Islands in 1958, made six principal study recommendations:

1. A system for collection and analysis of epidemiological data should be devised to observe incidence trends and establish more clearly the relationship of symptoms with species of fishes involved, their origin and environment, and the mode of handling them after catching.

At present, the authors said, considerable confusion surrounds the relationship of potentially toxic fishes to illness in humans. There has been no systematic analysis of large numbers of cases to indicate the varieties of poisoning. As human symptoms may be numerous and varied, the authors stressed the value of a controlled analysis of clinical observations relating them to fish species and laboratory studies. Fish poisoning incidence trends also should be evaluated in relation to weather, water characteristics, and other environmental phenomena in an effort to detect significant influences.

2. A phase of study should be devoted to de-

veloping more effective therapy for victims of fish poisoning. Current treatment is only symptomatic and employs a wide range of medications.

3. A simple on-the-spot test should be developed to determine whether a fish is safe to eat and to relate the quantity of poison present in a fish to the quantity that will cause human illness.

4. Pharmacological studies are needed to determine the physiological response of test animals to fish toxins to provide for a more rational approach to diagnosis and therapy and a better understanding of the biological activity of fish toxins. Such studies will require large quantities of poisonous fish material and will pose collection difficulties.

5. To obtain toxic fish specimens for study, advantage should be taken of the normally occurring fish poisoning episodes among the inhabitants of the Marshall Islands and other populations in poisonous fish areas. In addition, a systematic procedure should be developed for acquiring all of the following types of information when an episode occurs; symptoms occurring in humans, details of the causative fish's environment, symptoms occurring in laboratory animals fed a part of the same specimen used for other analyses, and human patient responses to a given therapy.

The general procedure in past studies has been to collect hundreds of fishes and to test all of them for toxicity by assay. Such costly and time-consuming effort to obtain one or two toxic specimens is exceeding inefficient, according to the authors, who maintained that the information obtained in this way can only relate toxicity to the response in test animals and fails to provide the more important knowledge of human symptoms in response to the toxin of a specific fish.

6. Ecologic study is proposed to determine if there is some dependable relationship between one or more identifiable variables in the environment and the appearance of toxic fishes.

Though no way is known to predict toxicity in fishes at a given locality, the formation of toxins appears to be a response to some influence in the environment and perhaps involves feeding habits and susceptibility of fish species. If relationships between environment and appearance of toxic fishes are discovered, Bartsch and McFarren suggested, poisoning episodes might be prevented by avoiding susceptible groups of fishes or by controlling the causes of toxicity.—R. M.

SALAMANDRISCHE WELT, AMPHIBIEN UND REPTILIEN (Salamandrian world, Amphibians and Reptiles). By Richard Gerlach. Claassen Verlag. Hamburg, 1960. 264 pp., 32 plates (DM 19.50—approx. $5.00).—This title is somewhat misleading, representing the author's attempt to foist off a *nomen novum*, after first and foolishly invalidating such terms as herpetology. Actually this volume deals with reptiles and amphibians on a semipopular level. The author is a hobbyist and popularizer, who has written three similar books on other vertebrate groups. There is considerable information on each of the categories included, and the volume is written in a popular style and sprinkled with personal anecdote; so that it will probably appeal to the audience addressed. Emphasis is on central European forms, but there is considerable information on the fauna of other continents, and some very interesting material culled from Rudolf Mell's unpublished notes on Chinese snakes. Most references are to items in the German aquarium and terrarium journals. The illustrations are adequate, but of commonly seen forms, and include a posed view of *Dasypeltis* ingesting an egg. A final chapter deals somewhat randomly with herpetologists and their works.

This is the sort of book that would have received quite favorable reviews a decade ago, before the surfeit of authoritative and expensively and beautifully illustrated volumes—IF it were not for the abundance of errors. It is sad that such a plethora of anthropomorphisms should still be acceptable to publishers, and that no professional "salamandrologist" was permitted to review the manuscript. There are also many, often amusing, errors of fact, such as statements that caecilians have no gills (p. 13), all reptiles have an egg tooth (p 15), there are no salamanders south of Mexico (p. 28), *Amphiuma* reminds American negroes of Africa (p. 29), "bastards" are known only in one species of salamander and in birds (p. 37), the Galapagos are remnants of a sunk continent (p. 85), many Florida gator farms feed their livestock 5 tons of meat each day (p. 116), caimans perspire strongly (p. 122). a guard at the New York Aquarium died of *Heloderma* bite (p. 146), and that "spitting" snakes use air power for venom propulsion (p. 232).—Carl Gans, *Department of Biology, The University of Buffalo, Buffalo 14, N. Y.*

WELCHES TIER IST DAS? KRIECHTIERE UND LURCHE. (What animal is it? Reptiles and amphibians, 2nd revised edition). By Robert Mertens. Franckh'sche Verlagshandlung, Stuttgart, 1960. 98 pp., 48 pls., 12 pp. of textfigs. DM 8.50 (approx. $2.10).—The first edition of this useful field guide appeared in 1952 and was reviewed by K. P. Schmidt in Copeia, 1953(2):130. His favorable comments apply to the new edition

as well. Changes involve improvements in the illustrations and nomenclatorial revisions on the subspecies level. This remains a simple, useful and authoritative guide to the herpetofauna of Central Europe.—CARL GANS, *Department of Biology, The University of Buffalo, Buffalo 14, N. Y.*

THE HEAD SKELETON OF THE LIZARD. By Malcolm T. Jollie. Acta Zoologica, 1960, Band XLI, pp. 1–64, 15 figs. (Not for sale as separate). —This paper represents an interesting attempt by a comparative (avian) morphologist to describe "the variations of structure within this [the lizard] type." The bones and cartilages are discussed in sequence, presenting their variation within lizards and possible homologies to mammalian elements. A terminal statement discusses the affinities of the lizards. The evidence for analysis was drawn from three sources: The dissection of three species, dried skulls of 25 species from one collection and the literature.

It is always useful to have such summaries of variation within a single group, and the present compendium is no exception. The inevitable errors and points of disagreement do not affect this evaluation, nor is this the place to review them. However, the examination of a larger sample of the specimens and skulls, as well as a more thorough collation of the descriptions scattered in the literature might well have been justified. Many of the classical studies of Comparative Anatomy were based on similar numbers of species, but one suspects that such paucity mainly reflected inavailability of material. It might also be questioned whether the more than 3000 forms of lizards represent a "type", or whether the present paradigm is adequate to discuss the major categories or relationships of the lizards.—CARL GANS, *Department of Biology, The University of Buffalo, Buffalo 14, N.Y.*

EDITORIAL NOTES AND NEWS

Foreign News THE EDITORS are attempting to obtain information on international Ichthyological and Herpetological research. The assistance of the membership is requested.

Senckenberg Museum, Frankfurt a.m., Germany.—DR. ROBERT MERTENS, Director of the Senckenberg Natural History Museum and Research Institute since 1946, became emeritus on January 1, 1960. He is, however, active once more in the Herpetological Section. Last year Dr. Mertens went on herpetological collecting trips to the Island of Corfu and to the small islands in the Gulf of Salerno.

The Assistant in the Herpetological Section, DR. KONRAD KLEMMER, has been on a collecting trip since March in northwestern Africa and the Iberian Peninsula. In Morocco he had the opportunity to go on several excursions with M. G. PASTEUR and to obtain important zoogeographic information.

Ecole Normale Superieure.—The Zoological Laboratory of the Ecole Normale Superieure devotes a portion of its activity to the study of frogs, and especially of the frogs of West Africa. By virtue of bountiful collections the systematics of certain frogs—the *Ranides* in particular—is studied, partly with the aid of biometrical methods. The systematic revision of the genre *Ptychadena* is nearly complete (in collaboration with MR. J. GUIBE, of the Museum d'Historire Naturelle), and the study of the genre *Phrynobatrachus* is beginning. We plan a complete taxonomic osteological study of certain species and sub-species of Ranides, especially *Rana sensu lata, Phrynobatrachus, Arthroleptis,* and *Cardioglossa.*

The larval forms of West African frogs were discovered either in nature or by breeding. Their knowledge brings a useful supplement to the definition of the species.

Finally some very thorough research is devoted to the curious little viviparous toad *Nectophrynoides occidentalis,* whose area of distribution is a few kilometers square on the summit of Mt. Nimba in Guinea. The analysis of the annual ecological cycle, the variations of the endocrine glands, and a detailed embryological study is in progress as well as consideration of the intro-uterine metamorphosis and the activity of the thyroid and of the hypophysis.—LAMOTTE.

Fish & Fisheries Research in Indian Universities.—The coordination of fisheries research in India has been successful to some extent by the organization of Central fisheries department, besides the fisheries departments in the states. There is no gain saying the fact that the more profound fundamental work in fisheries in India is done at the Universities, the economic work being the main theme of the fisheries depart-

ments of Government. There is no mechanism to coordinate fisheries research at Indian Universities; and although the Radhakrishnan Committee and the Inter-University Board have laid down certain principles on coordination, they have remained mostly on paper. Besides, very little help is given to the many workers on fish and fisheries in Indian Universities either by the Universities themselves or by the Government.

Many of the Indian Universities have special M.Sc. courses in fishes, which include two papers, one dealing with structure, systematics, and relationship, and the other dealing with life-history, bionomics distribution and general fisheries. A list of Ph.D. theses shows ¾ of them to be of morphological nature, e.g., the anterior blood vessels, aortic ligaments, air-bladder, endoskeleton, lateral line sense organs, the structure of excretory organs; while a few theses on physiology of respiration, the functional anatomy of the bucco-pharyngeal region and the gut, the functional anatomy of the air bladder and Weberian ossicles, the embryology, bionomics and distribution of some of the freshwater fishes in India are a few of other works at Indian Universities, specially at Lucknow. Dr. S. M. Das and his team of workers at Lucknow have worked on fish-food, physico-chemical data of environment, plankton, bottom fauna and special biological *niches* in some freshwater fishes.

Newer trends in Ichthyological research are investigations on fish-hormones and induced breeding. Dr. Ramaswami at Bangalore and Dr. H. L. Chaudhri of Calcutta have investigated on induced fish breeding in the main. The present author and his scheme of research, are trying to unfold the structural bases of the hormones and their effects on the functioning of different systems of the fish, with reference to the environment.

Fish and Fisheries Research in Indian Universities.—1. *Agra.* a. Morphology of *Wallagonia attu.* b. Embryogeny and homology of Weberian ossicles. 2. *Alagarh.* a. Anatomy and bionomics of *Ophicephalus punctatus.* b. Observations on breeding of catfishes. c. Parasites of fresh water fishes. 3. *Allahabad.* a. Air-bladder of fishes of Allahabad. b. Skeleton of *Bagarius, Mastacembelus, Mystus.* c. Seasonal variation in gonads. d. Circulation in fishes. e. Structure and Biology of *Hilsa* at Allahabad. f. Comparative studies on Kidney of fishes. g. The pineal organ in fishes. 4. *Andhra.* a. Biological studies on *Sardinella* and *Dussumeria.* b. Studies on food of fishes. 5. *Banaras.* a. Pituitary in fishes. b. Urinogenital organs of some teleosts. 6. *Calcutta.* a. Studies in breeding of carps in Bengal. b. Life histories of carps and differences in their fry and fingerlings. c. Spawning and movements of *Hilsa.* d. Studies on the vertebral column and skeleton. 7. *Delhi.* a. Hydrobiology of some ponds, and tanks. b. Analysis of gut-contents. c. Morphology of the alimentary canal. 8. *Kerala.* a. Rearing of *Tilapia* and its widespread introduction. b. Paddy-cum fish culture with *Tilapia.* c. Feeding habits in relation to structure of the skull. d. Embryology of *Stigmatogobius.* 9. *Lucknow.* a. Food and feeding habits with gut modifications. b. On plankton, hydrology and bottom fauna of lakes and tanks. c. On the morphology and physiology of respiratory organs in fishes. d. Ecology of fresh water fishes of U.P. e. Anatomy of *Clarias batrachus.* f. The functional anatomy of the pituitary and its hormone-production. g. Comparative studies on excretion and kidney structure. h. Life histories of common cat-fishes of India. i. Systematics of fishes, age, and scale studies. j. Seasonal cycle of gonads in some fishes. 10. *Madras.* a. Plankton studies. b. Scales of fishes in relation to growth rate. 11. *Mysore.* a. Chondrocranium and skull of clupeid fishes. b. Induced breeding in cat fishes. c. Hybridization. 12. *Punjab.* (Hoshiarpur) a. Fishes of Punjab and their systematics. b. Food and feeding habits of Punjab fishes. c. Cytological studies; spermatogenesis of sharks, rays, skates and few Teleosts. d. Chemical nature of cytoplasmic constituents during different stages in growth in eggs. 13. *Rajasthan.* (Jaipur) The fisheries and biology of *Hemirhamphus,* in the Gulf of Mannaar and Palk Bay. Respiratory adaptations in some siluroid fishes of India. 14. *Osmania.* (Hyderabad) a. Structure, function and evolution of air breathing organs in fishes. b. Correlation between structure of alimentary canal and food in fishes. c. The pyloric caecae in fishes.—Dr. S. M. Das, Lucknow University, India.

The Oceanographic Research Institute operates at Durban, Natal, under the auspices of the South African Association for Marine Biological Research and the University of Natal, in conjunction with a very successful aquarium and oceanarium project. Dr. David L. Davies, Director reports that two main research projects are well under way. One, being carried out in connection with the SCOR Indian Ocean program, deals with primary productivity estimation, using Steeman-Nielsen's behavioral studies, investigations of shark attacks, experiments on methods of preventing such attacks, and the medical aspects involved. When new laboratories now being planned are available, a teaching department of oceanography, hopefully with a division of ichthyology, will be established.—Carl L. Hubbs.

European journey of fishery biologists.—Dr. Paul R. Needham and graduate student Mr.

ROBERT J. BEHNKE of the Department of Zoology of the University of California, spent the summer of 1960 studying and collecting salmon and trout in Europe. Flying to Europe in June a month ahead of Needham, Behnke met DR. CURT KOSSWIG of the Zoological Institute in Hamburg. The latter provided the services of MR. NICOLAUS PETERS, a student of his with an unusual facility with languages, to Behnke for a trip to Yugoslavia. They traveled in a Volkswagen camping bus ("Camper") fitted with a tank of formalin in a wicker basket on the roof. This stirred up considerable curiosity among the natives, most of whom thought it contained a wine supply for the trip. At Ljubljana, Yugoslavia, Professors Zei and Jelacin kindly arranged for visits to fish cultural stations in the province of Slovenia and for the collection of various salmonids in northern Yugoslavia. At Lake Ohrid in southern Yugoslavia through the kind cooperation of the Director, DR. SINISA STANKOVIC and the chief fish investigator, MR. SLAVE HADZISCE, a fine collection of *Salmothymus ohridanus* and *Salmo letnica* was obtained. *Salmo letnica* has three and possibly four populations in Lake Ohrid, very similar morphologically, but remaining discreet by the time and place of spawning. An excellent book, "The Balkan Lake Ohrid and its Living World," by Dr. Stankovic, was recently published (1960) as Vol. 9 of the series, Monographiae Biologicae. Leaving Lake Ohrid, Behnke and Peters drove north to Split on the Adriatic Sea. Near Split they were able to arrange for a collection of the rare, relict *Salmothymus obstrusirostris* from the Jadro River, and an endemic *Salmo trutta* from the Cetina River.

Behnke met Needham in Copenhagen in mid-July and they began collecting trout and salmon together in Denmark, using the "Camper" for transport. At the fishery laboratory at Charlottenlund Slot they met DR. KNUT DAHL, MR. GABRIEL SORENSON and other staff members who assisted their efforts in field collections. Samples of both sea-run and resident brown trout, *Salmo trutta*, were obtained. DR. KAJ BERG, director of the Freshwater Biological Laboratory of the University of Copenhagen at Hillerod, was also most helpful.

The next stop was at Anaboda in south-central Sweden where the Freshwater Research Station of the University of Lund is located and directed by DR. BRUNO BERZINS. Here Needham established his reputation as a fisherman by catching a 12 inch eastern brook trout on a fly.

Needham and Behnke next visited Stockholm, spending several days at the Institute of Freshwater Research at Drottningholm. The DOCTORS NIELSON, GUFSTAFSEN, and LINDSTROM gave a cordial welcome and directed them to fishery research centers on the Baltic between Stockholm and Ostersund. At Alvkarleby on the Dalalvan River, a biologist, MR. N. G. STEFFNER, helped them to secure another fine series of young sea trout and Atlantic salmon.

In Sundsvall, they met DR. BORJE CARLIN, fishery biologist with the Bergeforsen Power Company. A series of dams completely block salmon and trout spawning runs in the Indalsalven River there, so the fish are trapped at the lowermost dam for artifical propagation in a very large and modern hatchery located at nearby Bergeforsen. Automatic feeders in the form of small carts, run out on rails and drop measured amounts of food into each rearing pond and then return to the feed room for refills, making round-trips at electrically timed intervals. Feeding starts at 3:00 A.M. without requiring an attendant to be present. The entire station is largely automated with electricity performing most of the work. Their drip incubator for hatching eggs will handle 2.5 million eggs while using only 120 liters of water per minute. The capacity of the station is 320,000 Atlantic salmon smolts per year plus 40,000 young sea trout. Dr. Carlin indicated that in the Indalsalven River the fishery is completely dependent upon plants of hatchery smolts for the maintenance of its stocks of salmon. The catch in the summer of 1960 was over 10,000 salmon, whereas the biggest catch ever made by natural reproduction in earlier years was around 8,000 fish. They have tagged over half a million smolts to date and have recaptured approximately 27,000 adult salmon that weighed over 100 tons, indicating that their smolt program is producing large-scale returns of adults.

DR. CARLIN drove them up to the Holle Salmon Research Station some 50 miles north of Sundsvall, where they saw the underwater observation tank used by DR. ERIC FABRICIUS for making observations of the spawning habits of the char, *Salvelinus alpinus*. They also observed an underwater observation tank built as a part of the fish ladder at the foot of the Bergeforsen power dam. In one of the holding tanks next to the fish ladder, one goes down a winding steel stairway into a darkened room with a plate glass window through which, swimming majestically, one sees enormous salmon and sea trout. This is a real attraction to the visiting public and the room is crowded with people watching the fish. Such public viewing facilities might well be built into some of the fish ladders being constructed in the U. S. Bonneville Dam on the Columbia River, for instance, could use such an attraction.

Returning south again they stopped at Lake Erken near Uppsala, Sweden, where DR. WILHELM RODHE, in summers, directs the work of the

Limnological Institute of the University of Uppsala. This station has probably as good instrumentation as any limnological station in the world. Power cables are run on the lake bed to supply electricity to a small island some 200 yards off shore for various recording instruments which operate 24 hours a day.

Returning to Stockholm on July 30, Behnke flew to Helsinki, Leningrad, and Moscow, while Needham flew to northern Sweden to locate additional salmonids. Behnke wrote as follows regarding his experiences:

"In Leningrad I worked in the ichthyological collections of the Zoological Institute of the Academy of Sciences, under the direction of Dr. A. N. Svetovidov who speaks fluent English. Here I examined specimens of European, Siberian, and Asiatic salmonids. Their ichthyological collection is one of the finest in the world. Dr. Svetovidov asked me if I had encountered any 'iron curtain'. When I assured him I had not, he urged me to tell other American ichthyologists that they too, would be most welcome to visit the U.S.S.R. and use the facilities and specimens of the Academy. Dr. Svetovidov has an immense knowledge of fishes. His main interest concerns the functional morphology of fishes. I consider our frequent discourses on various problems of ichthyology as one of the most enriching experiences of my summer's travels. Of interest to North American ichthyologists is a comparative study of European and North American *Perca*, *Lucioperca*, and *Stizostedion* being carried out by Dr. Svetovidov and a young woman student. North American specimens are supplied by Dr. Reeve M. Bailey of the University of Michigan. The other full-time ichthyologists of the Academy at Leningrad are Drs. Andriashev, Lindberg, and Barsakov.

After a week in Leningrad, I worked for one week in the collections of Moscow University. Dr. Svetovidova, a niece of Dr. Svetovidov, is in charge of this collection. She provided me with the services of the technical assistant who was most helpful. In Moscow, I met Dr. N. V. Parin, one of the Soviet Union's most outstanding young ichthyologists. He was completing his Ph.D. study of flying fishes. I also met Donald Bevan of the University of Washington, School of Fisheries. He was just completing a year's study of Pacific salmon with Dr. Nikolsky at Moscow University. Except for restrictions on where I lodged, there were no questions or interference with my movements or work in Moscow or Leningrad. From a scientific and cultural viewpoint, my visit was most successful. I look forward hopefully to the time when the exchange of scientists between the U.S.S.R. and the United States is more easily arranged. I finished my European tour at the British Museum in London on September 15."

Needham and Behnke separated in Stockholm and did not meet again in Europe. Needham reports as follows on his portions of the trip:

"Returning to Copenhagen, where Mrs. Needham joined me, we picked up a car and drove through much of the area where the best trout waters are located in southern Germany, Switzerland, Austria, and Italy. In Rome we had a profitable visit with Mr. William A. Dill and Dr. William Beckman, who work for the fishery section of the Food and Agriculture Organization of the United Nations. In Genoa we had a fine visit with Dr. Enrico Tortonese, ichthyologist with the Civic Museum there. I borrowed quite a few of his salmonid specimens on loan for study in Berkeley. After Genoa, we drove up to Lake Garda where I was unable to secure specimens of the two sympatric species of *Salmo* occurring there because it was the wrong time of the year and none were being taken. At Torbelo at the upper end of Lake Garda, I saw a most efficient commercial trout rearing establishment. Professor Mondelli, who operates it, sells tons of our famous, imported *Salmo gairdneri*, to hotels and restaurants all over northern Italy. Cyprinids are seined from Lake Garda, ground up, and fed to trout in the many rearing ponds. The trout seen out of water were beautifully formed and of brilliant color.

In Brussels I had several profitable sessions with Dr. Marcel Huet of the University of Louvain. He directs the Station de Recherches des Eaux et Forets at Groenendaal-Hoeilaart, five miles outside Brussels. At his experimental station at Linkebeek, another five miles distant, he has some 30 experimental ponds with around four surface acres of water. It is here that many of his researches on the culture of fishes has been done, many of which are reported in his "Traite de Pisciculture," of which a new 1960 edition is now available.

We arrived in London on October 1, and spent the next few days with Dr. J. W. Jones of the University of Liverpool, who did such excellent work on the natural spawning of the brown trout and Atlantic salmon. His observation tank, constructed on the side of the River Dee, was still intact and cold and damp. Jones spent many thousands of hours watching spawning activities and recording his observations in motion pictures there, bundled "to the ears", to keep from freezing in the raw, English, fall climate.

From Liverpool I visited, as did Behnke just before me, the Freshwater Biological Association headquarters at Ferry House on Lake Windermere. Among other things, Dr. Winifred Frost took me to the small "beck" (stream) where Dr

LE CREN is doing much excellent work on trout, and I had fine visits with various staff members. Returning to London on October 7, I spent the remaining time seeing various persons connected with fisheries research at the British Museum or others concerned with management of private trout waters near London. DR. ETHELWYNN TREWAVAS and DR. PERCY H. GREENWOOD at the British Museum, were especially cordial and helpful, as they were to Mr. Behnke.

In all we obtained some 35 lots of trout and other fishes on the trip and learned much that we can apply towards our own studies of salmonids."

News Notes

RECENT APPOINTMENTS to the staff of the U. S. Bureau of Commercial Fisheries' Honolulu Biological Laboratory include appointment of DR. LUCIAN M. SPRAGUE as chief of Sub-population Investigations and WILVAN G. VAN CAMPEN as head of Scientific Services. Sprague will study the identity and distribution of blood-group systems in fishes, particularly tunas, and the genetics of fishes in general. Van Campen will serve as scientific editor for the laboratory.

New Series of Oceanic Atlases. A new series of oceanic atlases was recently launched by the Woods Hole Oceanographic Institution with the publication of *The Atlantic Ocean Atlas of Temperature and Salinity*. The atlas was prepared by Frederick C. Fuglister and his associates as part of the institution's contribution to the International Geophysical Year. It represents many months of labor-making measurements at sea, compiling the data, and carefully preparing the final charts.

The core of the book is a section of 46 large colored charts, or profiles, which show the salinity and temperature of the North and South Atlantic oceans from the surface to the bottom. Eight other profiles in color, the first of their kind to be published, give more detailed temperature information for the top 500 feet of water all the way across the ocean at different latitudes. In addition, all the data from which the profiles were drawn are included in the 210-page volume.

Printed on paper which was especially made for durability at sea, the publication is designed as both a reference book and a working tool for oceanographers, fishery scientists, submarine warfare specialists, and other students of the sea. Temperature and salinity information is basic to oceanic research for calculating water density and the distribution and movement of large masses of water.

The new atlas is the most complete collection of such data since the publication of the results of the expedition of the German ship *Meteor*, 1925–27; however, the *Meteor* concentrated on the South Atlantic and the Woods Hole work covers both the North and the South Atlantic.

The observations for the atlas were taken between September 1954 and July 1959 by scientists aboard the research vessels *Crawford, Atlis,* and *Chain* of the Woods Hole Oceanographic Institution and *Discovery II* of the National Institute of Oceanography in England. In a methodical survey these vessels made 11 transatlantic passages between 32°S and 48°N and 12 shorter cruises in the North Atlantic and the Caribbean Sea. Some of the profiles, purposely made along the track of the *Meteor*, show a distribution of temperature and salinity in the deep water virtually identical with that of 30 years ago, indicating a basic stability of deep oceanic structure.

The chief scientists for the data-gathering cruises were Fuglister, L. Valentine Worthington, William G. Metcalf, and Arthur R. Miller, all physical oceanographers at Woods Hole. The work was supported by the National Science Foundation and the Office of Naval Research.

The first edition of the atlas (3000 copies) was financed by NSF in support of its IGY Interdisciplinary Research Program. Copies may be purchased from the Woods Hole Oceanographic Institution. Work is now in progress on a second volume, which will present data from world-wide study of the deep ocean.

WILLIAM M. MANN, Washington, D. C. died 10 Oct. 1960 at age 74. He retired in 1956 after 31 years as director of the Washington Zoo, which is operated by the Smithsonian Institution. He was assistant director of the Mulford Biological Exploration in the Amazon Basin in 1921–22, director of the Smithsonian Chrysler Expedition to Africa in 1926, and director of the National Zoological Park expeditions to British Guiana in 1931, to Argentina in 1938, and to Liberia in 1940 and in 1937 directed the National Geographic Society expedition to India.

JOHN P. WISE, biologist at the Fisheries Laboratory, Woods Hole, for the past 7 years, is transferring to the Food and Agriculture Organization of the United Nations to serve as an advisor in fisheries biology in Argentina, Brazil, and Uruguay.

U. S. Oceanographic Study.—The United Nations is planning an extensive study of the world's major bodies of water. Fish will be counted, fertlity and productivity studied, and the floors of oceans mapped. ROGER REVELLE of the Scripps Institution of Oceanography, a member of the national committee of the United Nations Educational, Scientific and Cultural Organization, recently announced plans for the international cooperative program, which is expected to cost

contributory nations a total of $20 million a year. UNESCO will provide $500,000 for the first 2 years of operation.

PHILIP J. DARLINGTON, JR., of the Museum of Comparative Zoology at Harvard University, has won the National Academy of Sciences Daniel Giraud Elliot Medal for his 675-page study, *Zoogeography: The Geographical Distribution of Animals*. The medal, awarded for the most meritorious work in zoology or paleontology published during a previous year, will be presented during the annual meeting of the Academy in Washington on 24 April.

A member of the museum staff since 1932, Darlington is especially known for his taxonomic work on ground beetles and for his study of the distributions of animals over the earth. For some 30 years he has collected insects, birds, amphibians, and reptiles for the museum in Australia and the West Indies.

Animal Behavior Center. An unusual field station, the University of California Field Station for Research in Animal Behavior, is soon to be erected in the hills east of Berkeley. Construction funds of $367,700 have been provided by the National Science Foundation. The station, which is expected to be ready for occupancy in 1962, will be staffed by professors from the departments of psychology, zoology, and anthropology. Frank A. Beach, professor of psychology, is largely responsible for planning the new center, which will have ten or so structures and facilities, including tanks intended for fishes, amphibians, or reptiles but drainable for use by small animals; bird observation cages expressly designed for photography, tape recording, and observation; a mammal enclosure, of about an acre, for group studies of dogs, sheep, or goats, and a monkey facility with observation platforms.

1962 Limnology Congress.—The 15th International Congress of Limnology will be held at the University of Wisconsin, 20–25 August 1962. The congress is sponsored in North America by the American Society of Limnology and Oceanography and cosponsored by the National Academy of Sciences-National Research Council and the International Society of Theoretical and Applied Limnology. The congresses are held triennially, and all previous congresses have been held in Europe. Inquiries should be addressed to: The XVth International Congress of Limnology, Dr. John C. Wright, Birge Hall, University of Wisconsin, Madison 6.

Deep Canyon Desert Research Area.—The University of California has established the Deep Canyon Desert Research Area at the western edge of the Colorado Desert near Palm Springs, California. This 10,000 acre preserve is some 75 miles from the Riverside Campus of the University and includes the lower gorge of Deep Canyon located at the base of the Santa Rosa-San Jacinto Mountains and has a range of elevations from 700 to 4600 feet. A small laboratory, designed to house a maximum of four investigators is under construction. The control committee invites inquiries regarding the use of the area for long-term studies. Address inquiries to: Control Committee, Deep Canyon Desert Research Area, Division of Life Sciences, University of California, Riverside, California.

The National Science Foundation and the Office of Naval Research are jointly sponsoring a First National Shallow Water Research Conference on a regional basis at three locations this Fall. The Pacific Coast regional conference will be held at the Allan Hancock Foundation, University of Southern California, Los Angeles on October 27 and 28. Scientists in all disciplines working in the area of the continental shelf and coastal region are invited. Limited expense funds are available for participants whose local travel budgets are restricted.

BOOKS RECEIVED

Zoological Record, 1958

SIMPSON, G. G. "Principles of Animal Taxonomy," 1961, Columbia University Press, 247 pp. $6.00

CAIN, A. J. "Animal Species and Their Evolution," Harper Torchbooks. $1.35

IVLEV, V. S. "Experimental Ecology of the Feeding of Fishes," 1961. Yale University Press, New Haven. 302 pp. $7.50

SMITH, ARTHUR C. "Western Butterflies," 1961. J. B. Lippincott Company, Philadelphia. 59 pp. $2.95

TEMBROCK, DR. GÜNTER. "Verhaltensforschung—Eine Einführung in die Tier-Ethologie," 1961. Veb Gustav Fischer Verlag Jena. 371 pp.

PURCHON, R. D., Editor. Proceedings of the Centenary and Bicentenary Congress of Biology. Singapore, December 2–9, 1958. University of Malaya Press, 1960. Singapore. 333 pp. Price in Malaya only $13.50 net

FITCH, HENRY S. "Autecology of the Copperhead," 1960. University of Kansas, Lawrence. 288 pp.

BOGERT, CHARLES M. "The Influence of Sound on the Behavior of Amphibians and Reptiles," 1960. Reprinted from "Animal Sounds and Communication," American Institute of Biological Sciences, Publication No. 7, 1960.

SUGGESTIONS FOR AUTHORS

Authors can assist the editors, speed the publication of their manuscripts, and help the society stay within its budget by following these suggestions.

The Style Manual for Biological Journals (American Institute of Biological Sciences, 2000 P St., N.W., Washington 25, D.C., $3.00) will be followed in all details not specifically covered below. Authors are urged to obtain copies for themselves and for the libraries of their institutions. The following are items which we feel require emphasis or specification:

(1) All manuscripts must be submitted on good bond paper. (*NOT* erasable bond.)

(2) All material—text, tables, bibliography, and legends—*must be double-spaced.*

(3) Common names are not to be capitalized in text use. Common names shall conform to the lists published by A.S.I.H. and the American Fisheries Society.

(4) The author is responsible for putting his manuscript in final form for publication. The cost of galley changes, other than corrections of printer's errors, *will be charged to the author.* Reprints are supplied at approximate cost.

(5) Withdrawal of manuscript after type has been set will be permitted, but the author must reimburse the Society for the expense of setting type.

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